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A Delphi Study
Volume I

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In the first round survey, there was good agreement among the panel experts for the health effects of oxidant on all categories of population, while the data for both carbon monoxide and nitrogen dioxide was much less so. The results of the second round survey showed improvement in group agreement for all three pollutants.

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HUMAN HEALTH DAMAGES FROM MOBILE SOURCE AIR POLLUTION:

A DELPHI STUDY - VOLUME I

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FORWORD

Effective regulatory and enforcement actions by the Environmental Protection Agency would be virtually impossible without sound scientific data on pollutants and their impact on environmental stability and human health. Responsibility for building this data base has been assigned to EPA's Office of Research and Development and its 15 major field installations, one of which is the Corvallis Environmental Research Laboratory (CERL).

The primary mission of the Corvallis Laboratory is research on the effects of environmental pollutants on terrestrial, freshwater, and marine ecosystems; the behavior, effects and control of pollutants in lake systems; and the development of predictive models on the movement of pollutants in the biosphere.

A. F. Bartsch
Director, CERL

ABSTRACT

During the past year, the California Air Resources Board conducted a survey of 14 health experts on the human damages from mobile source air pollution.

A variant of the Delphi technique was used in the study to arrive at a consensus judgment of the experts on the dose-response relationship for photochemical oxidants, nitrogen dioxide and carbon monoxide. The panel experts were requested to answer questionnaires to provide dose-response for all three pollutants and for healthy individuals as well as diseased or sensitive persons. The completed questionnaires were analyzed and the group consensus were sent to the panel members. The panel experts were then asked to answer the same questionnaires again for a second time. The data obtained during the second round represents the final group consensus.

In the first round survey, there was good agreement among the panel experts for the health effects of oxidant on all categories of population, while the data for both carbon monoxide and nitrogen dioxide was much less so. The results of the second round survey showed improvement in group agreement for all three pollutants.

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This report is dedicated to the memory of Mr. Dale H. Hutchison who, first conceived of this project, served as Chief of the Air Resources Board's research program until his death on August 29, 1973. Widely recognized as a pioneer in the field of air pollution research, his leadership, wisdom and humor are missed by all.

SECTION 1

EXECUTIVE SUMMARY

This report discusses the results of a survey among a group of 14 health experts on the human damages from mobile source air pollution. This survey includes three major air pollutants, photochemical oxidant, nitrogen dioxide, and carbon monoxide. The study was supported by the U.S. Environmental Protection Agency.

The research method used in this study was a variant of the Delphi technique. This approach uses a panel of experts to arrive at a group consensus on the dose-response relationship for each of the pollutants. This method improves the quality of judgments of relatively uncertain issues by experts. The basic assumption is that the most accurate assessment of a problem where data is incomplete can be obtained by canvassing a group of experts and accepting the group consensus.

The Delphi technique involves three steps. Estimates are first obtained independently from the experts. The panel is then informed of the distribution of answers on the first round, and is asked to reestimate their answers for questions with large disagreement. The third step involves the compilation of the final estimates which include answers of the second round and those in the first round with good agreement. In this study, these final estimates were reported in the form of median and interquartile range. Answers from each round were also reduced and expressed in a S-shaped dose-response curve by using the logistic distribution model. The accuracy of these group responses were evaluated by means of the data dispersion and self-confidence ratings.

In arriving at the group estimates, the experts were asked to answer a set of questionnaires. The questionnaire was designed to allow the experts to estimate one hour concentrations of oxidant, nitrogen dioxide, or carbon monoxide which would induce specific functional abnormalities in 14 population categories.

These categories are:

- Normal
- Children
- Old Age
- Heart Condition, Mild
- Heart Condition, Severe
- Hay Fever, Sinusitis
- Influenza
- Upper Respiratory Infection
- Asthma
- Acute Viral Bronchitis
- Acute Bacterial Pneumonia
- Chronic Respiratory Diseases
- Mild Chronic Obstructive Lung Disease
- Severe Chronic Obstructive Lung Disease

The population varies significantly in their response to a given pollutant exposure independent of the health status of the group. The questionnaire considered this variation by querying the concentration at which 90%, 50%, 10%, and 0% of the population would be expected to manifest the stated abnormality. In addition to estimating these points, the experts indicated a range of pollutant concentrations for each dose-response result to allow limits for each estimate. The experts also estimated the duration in hours of the abnormalities. Self-ratings were given for each of the answers.

The first round data were analyzed for group agreement with the feed-back criterion. Those answers with interquartile range greater than one-half of the median were fed back to the panel members for re-estimation. Using this stringent criterion, two-thirds of the estimates for oxidant, about 90% of the estimates for CO, and all of the estimates for NO_2 were iterated.

The second criterion used for validity measurment in the study was self-confidence rating. The rating ranges from 1-10, where 1 meant "the answer is a sheer guess," and 10 meant "the panelist knows the answer very well." An average self-rating of 5 or higher was used as the cut-off point for acceptable confidence score. Based on this self-rating scale, the experts have higher confidence in their answers for photochemical oxidant and carbon monoxide questionnaires than those for nitrogen dioxide. The panel members gave an average self-rating score of 5 or higher in about 50% of their answers for both the photochemical oxidants and carbon monoxide questionnaires, and only in 25% of their answers for nitrogen dioxide.

A different criterion was used to evaluate the degree of agreement within the group on answers in the second round. The estimate is considered to have good group agreement if its standard deviation is equal to or less than one-third of the median value. Based on this criterion, good agreement is observed in 58%, 17% and 8% of answers for the photochemical oxidants, carbon monoxide and nitrogen dioxide questionnaires, respectively. In comparison with the first round data, there is a definite improvement in group agreement in the second round.

The final best estimates of pollutant concentrations causing incapacity, disability and discomfort for all population categories in different affected population fractions are summarized in Tables 1-3.

TABLE 1: Final Best Estimates, Photochemical Oxidant Concentrations (ppm)
Incapacity, Disability and Discomfort in Different Population Fractions

Population Category	Incapacity				Disability				Discomfort			
	0%	10%	50%	90%	0%	10%	50%	90%	0%	10%	50%	90%
Normal	0.30	0.77	1.02	1.50	0.20	0.41	0.80	1.00	0.10	0.30	0.50	0.80
Children	0.30	0.70	1.00	1.40	0.20	0.50	0.70	1.00	0.10	0.30	0.50	0.75
Old Age	0.32	0.70	1.00	1.40	0.20	0.55	0.72	1.00	0.10	0.30	0.50	0.70
Heart Condition, Severe	0.30	0.60	0.95	1.20	0.23	0.52	0.77	1.00	0.15	0.40	0.50	0.75
Heart Condition, Mild	0.35	0.80	1.00	1.45	0.20	0.60	0.80	1.15	0.15	0.40	0.50	0.70
Hay Fever, Sinusitis	0.27	0.60	0.85	1.00	0.20	0.50	0.65	0.80	0.10	0.30	0.40	0.50
Upper Respiratory Infection	0.30	0.62	0.92	1.20	0.20	0.50	0.67	0.95	0.10	0.30	0.50	0.70
Asthma	0.30	0.60	0.80	1.00	0.20	0.40	0.60	0.80	0.10	0.30	0.40	0.60
Viral Bronchitis	0.30	0.60	0.85	1.20	0.20	0.40	0.55	0.80	0.10	0.30	0.40	0.60
Bacterial Pneumonia	0.30	0.75	0.92	1.20	0.20	0.50	0.60	0.80	0.10	0.30	0.40	0.55
Influenza	0.30	0.65	0.82	1.00	0.20	0.40	0.60	0.80	0.10	0.30	0.40	0.60
Chronic Respiratory Disease	0.35	0.62	0.93	1.45	0.20	0.47	0.70	1.05	0.10	0.30	0.50	0.60
Mild Chronic Obstructive Disease	0.32	0.80	1.00	1.20	0.20	0.50	0.80	1.00	0.10	0.40	0.52	0.60
Severe Chronic Obstructive Disease	0.20	0.50	0.75	1.00	0.13	0.40	0.55	0.75	0.10	0.20	0.32	0.42

TABLE 2: Final Best Estimates, Carbon Monoxide Concentrations (ppm)
Incapacity, Disability and Discomfort in Different Population Fractions

Population Category	Incapacity				Disability				Discomfort			
	0%	10%	50%	90%	10%	10%	50%	90%	0%	10%	50%	90%
Normal	110.0	205.0	262.5	300.0	80.0	160.0	182.5	225.0	45.0	100.0	120.0	140.0
Children	100.0	187.5	235.0	300.0	60.0	145.0	165.0	200.0	35.0	80.0	105.0	120.0
Old Age	100.0	180.0	210.0	300.0	62.5	240.0	167.5	200.0	32.5	80.0	103.5	130.0
Heart Condition, Severe	60.0	100.0	180.0	190.0	45.0	80.0	122.5	150.0	25.0	55.0	65.0	90.0
Heart Condition, Mild	77.5	160.0	190.0	215.0	50.0	120.0	150.0	170.0	30.0	72.5	110.0	119.0
Hay Fever, Sinusitis	97.5	170.0	250.0	300.0	60.0	130.0	165.0	200.0	40.0	80.0	115.0	135.0
Upper Respiratory Infection	100.0	167.5	225.0	300.0	60.0	125.0	170.0	200.0	40.0	80.0	105.0	140.0
Asthma	100.0	172.5	225.0	300.0	60.0	140.0	165.0	197.5	37.5	84.0	110.0	130.0
Viral Bronchitis	100.0	162.5	215.0	300.0	65.0	120.0	160.0	200.0	40.0	80.0	100.0	131.0
Bacterial Pneumonia	100.0	170.0	200.0	215.0	60.0	115.0	150.0	180.0	40.0	77.5	100.0	120.0
Influenza	97.5	151.0	215.0	300.0	60.0	120.0	167.5	200.0	35.0	70.0	105.0	135.0
Chronic Respiratory Disease	100.0	150.0	200.0	225.0	59.0	110.0	155.0	180.0	39.5	75.0	95.0	125.0
Mild Chronic Obstructive Disease	100.0	152.5	205.0	275.0	60.0	127.5	155.0	190.0	40.0	65.0	100.0	140.0
Severe Chronic Obstructive Disease	92.5	140.0	180.0	205.0	60.0	100.0	140.0	170.0	32.5	60.0	90.0	100.0

TABLE 3: Final Best Estimates, Nitrogen Dioxide Concentrations (ppm) Incapacity, Disability and Discomfort in Different Population Fractions

Population Category	Incapacity				Disability				Discomfort			
	0%	10%	50%	90%	0%	10%	50%	90%	0%	10%	50%	90%
Normal	4.70	2.50	8.00	10.00	1.60	3.75	4.50	6.00	1.00	2.50	3.25	4.90
Children	4.25	2.50	6.50	8.00	1.60	3.35	4.25	5.50	1.05	2.20	3.00	4.65
Old Age	3.85	2.25	6.00	8.00	1.50	3.00	4.00	5.00	1.20	2.00	3.00	4.00
Heart Condition, Severe	3.45	1.90	6.00	8.00	1.55	2.90	4.00	5.50	0.75	2.00	3.00	3.50
Heart Condition, Mild	3.85	2.35	5.50	8.00	1.60	3.10	4.15	6.00	1.00	2.00	3.10	4.00
Hay Fever, Sinusitis	3.50	2.50	5.50	7.00	1.70	3.00	4.00	5.50	1.15	2.40	3.50	4.00
Upper Respiratory Infection	3.50	2.25	4.50	5.75	1.50	3.00	3.75	4.75	1.00	2.10	3.10	4.00
Asthma	4.00	2.00	5.00	6.00	1.60	3.15	4.00	5.00	1.10	2.45	3.00	4.00
Viral Bronchitis	3.75	2.50	5.50	7.00	1.50	3.00	4.00	5.00	1.25	2.10	3.15	4.00
Bacterial Pneumonia	4.25	2.10	5.50	6.50	1.50	2.75	4.00	5.00	1.00	1.85	3.25	4.00
Influenza	3.50	2.45	4.50	6.00	1.75	3.00	4.00	5.00	1.30	2.10	3.00	3.85
Chronic Respiratory Disease	3.75	2.60	4.90	6.00	1.75	3.30	4.20	5.00	1.00	2.00	3.20	3.70
Mild Chronic Obstructive Disease	3.50	2.35	4.85	6.00	1.60	2.90	3.65	4.80	1.00	1.60	2.65	3.55
Severe Chronic Obstructive Disease	3.00	1.75	3.60	4.50	1.30	2.35	3.05	3.60	0.75	1.50	2.10	3.00

In examining the Delphi data and the available experimental data, it is observed that these data are comparable to each other. The limited number of "good agreement" answers in the finalized results, especially in the area pertaining to the health effects of nitrogen dioxide and carbon monoxide, is really a reflection of the lack of actual data to form a basis for the panelists to come to a better group agreement.

Based on the interpretation of data obtained in this study, one may conclude that Delphi technique is appropriate for formulating group judgments in the air pollution health effects area. In the absence of experimental data, use of Delphi techniques to obtain a broad and well-informed opinion from a group of experts offers an important alternative to air pollution control agencies for making decisions.

SECTION 2

CONCLUSIONS

The following conclusions are based on the interpretation of data obtained in this study.

1. Delphi techniques are appropriate for formulating group judgments in the air pollution health effects area. In the absence of experimental data, use of Delphi techniques to obtain a broad and well-informed opinion from a group of experts offers an important alternative to air pollution control agencies for making decisions.

2. According to the best estimates of the panel, the oxidant threshold level in normal individuals for one hour exposure ranges from 0.05 to 0.20 ppm. The threshold concentration is lowered among young and old individuals, and also those with underlying disease. Those with respiratory and chronic obstructive diseases are most sensitive to the photochemical oxidants, and the threshold levels for these population groups range from 0 to 0.20 ppm.

   The health effects of nitrogen dioxide on different population groups follow a similar trend as the oxidant. The threshold level of NO_2 for one hour exposure in "normals" ranges 0.50-1.90 ppm. The experts suggest that individuals with severe heart condition are most sensitive to NO_2, with a threshold concentration range of 0.20-1.45 ppm. Nitrogen dioxide also has a profound effect on individuals with respiratory and chronic obstructive diseases. The threshold level for the latter population group is 0.30-1.65 ppm. Carbon monoxide exerts its effects mainly in impairing the oxygen carrying capacity of hemoglobin. Individuals with heart conditions are therefore most susceptible to its effects. The threshold level of CO for one hour exposure on people with heart condition is 10-50 ppm, while the threshold level in "normals" is 21-72.5 ppm. Individuals with obstructive disease are also quite sensitive to the CO effects, with a threshold level of 17.5-52.5 ppm.

3. Based on the dispersion of data in this study, there is a tremendous lack of experimental information in the field of air pollution health effects. This is especially true for nitrogen dioxide and carbon monoxide.

SECTION 3

RECOMMENDATIONS

1. A similar study using the Delphi approach, but with separate panels for each pollutant, should be undertaken. This will help to obtain more accurate and uniform data.

2. In view of the big gap in the air polltuion health effects knowledge, governmental and other funding agencies should initiate more intensive research programs to fill in this gap.

3. If the dose-response estimates contained in the present report are used in policy deliberations, close attention should be paid to the degree of group consensus and panelists' confidence in their own answers.

SECTION 4

INTRODUCTION

In recent years much evidence has accumulated which indicates that ozone, nitrogen dioxide, and carbon monoxide may be hazardous to health.[1-6] The extent of this hazard depends on the toxicity and concentration of the pollutants, the duration of exposure, and the health status of the individuals who are exposed. Information for assessing human risk due to air pollution has been obtained from epidemiological investigations, volunteer studies, and animal experimentation. Although these studies have yielded valuable data, the complexity of the problem of air pollution is such that at present the results do not define dose-response relationships of normal or inordinately susceptible individuals except for those cases in which the exposures are above ambient pollutant concentrations. The estimates of the dose-response relationship in humans must be developed if the public is to be protected from possible health effects of air pollution.

In May 1973, the California Air Resources Board responded to a request for proposal by the Environmental Protection Agency entitled "Human Health Damages from Mobile Source Air Pollution" and submitted a proposal to estimate "rough order" physical dose-response relationships for mobile source air pollutants. The purpose of this project is to determine the dose-response relationships for carbon monoxide, nitrogen dioxide and photochemical oxidants. Such a study is of importance not only in providing information to protect the public but also to generate data for estimating the cost benefit of air pollution control. This proposal was accepted and initiated on July 1, 1973.

A variant of the Delphi techniques was proposed to arrive at a consensus judgment of a panel of experts on the dose-response relationship for each of the pollutants. This method improves the quality of judgments of relatively uncertain issues by experts and allows an improved measure of accuracy and consistency of judgment. The basic assumption is that the most accurate assessment of a problem where data is incomplete can be obtained by canvassing a group of experts and accepting the group consensus.

SECTION 5

RESEARCH METHODS

A. GENERAL DESCRIPTION

The Delphi techniques used in this study were generated at the RAND Corporation to provide a method for the systematic aggregation of expert judgment.[7] These techniques are most useful where insufficient data exist to derive meaningful policy. In such cases, these techniques are used to obtain informed judgmental data in the place of actual experimental data.

Delphi procedures have been applied to a wide range of studies, including long-range forecasts of economic and technological developments for industrial decision-making, estimation of costs for new product developments, estimation of incidence of various disease states in the total population, and many others. An assessment of Delphi for this type of application is found in reference 8.

The basic justification for using the Delphi techniques is the elementary fact that, given a distribution of estimates from a panel of experts, the error of the mean of those estimates will be less than, or at worst, equal to the average error of the individual estimates. Depending on the shape of the distribution, other measures of central tendency such as the median or geometric mean may be more appropriate than the mean.[9]

The Delphi technique involves three features: (1) Anonymity -- estimates are elicited independently from each of the panelists; (2) Iteration and controlled feedback -- for questions with large disagreement on the first round, the panel is informed of the distribution of answers on the first round and asked to reestimate their answers; and, (3) Statistical group response -- rather than asking the group to arrive at a single "concensus," the distribution of estimates on the final round is reported in the form of the median and the interquartile range. This group response assures that all panelists' judgments are included in the final estimate, and furnishes a measure of the degree of agreement.

A group of 14 physicians and scientists were employed as the expert panel members for this study. These panel members were queried and their anonymously submitted answers together with a self-confidence rating of from 1-10 for each answer were collated, analyzed and returned for a second iteration. This "feedback" is used by the experts to reestimate answers to the original questions. Answers from each round were reduced and expressed in a S-shaped dose-response curve by using the logistic distribution model. The accuracy of these group responses were evaluated by means of the data dispersion and self-confidence ratings.

The fourteen panel members are listed below:

- Oscar Balchum, M.D.
- T. Timothy Crocker, M.D.
- Carroll Cross, M.D.
- Richard Ehrlich, M.D.
- Gustav Freeman, M.D.
- Elliot Goldstein, M.D.
- Jack Hackney, M.D.
- Steve Horvath, Ph.D.
- Paul Hoeprich, M.D.
- Glen Lillington, M.D.
- Homer Peabody, Jr., M.D.
- Stanley Rokaw, M.D.
- Carl Shy, M.D.

B. MEASURES OF CENTRAL TENDENCY

In a Delphi exercise, each panelist independently estimates some quantity of interest -- in the present case the dose required to produce a given type of impairment in a given percentage of a specified population. The data are analogous to independent measures of a quantity by a fallible instrument, e.g., the set of numbers that would be obtained by repeated measurements of the length of a table with a yardstick. In the theory of errors applied to such a case, it is assumed that the variant readings result from random errors which are distributed normally with zero mean. Thus the mean of the measurements is the best estimate of the actual length of the table.

When the distribution of responses is highly skewed, as in the present study, the mean is usually not the most appropriate measure of central tendency. The data from the present study are in accord with a large number of experimental studies in which the distributions tend to be log-normal.[10] For a theoretical log-normal process, the population is distributed normally on the logarithm of the independent variable. Let μ and σ be the mean and standard deviation of the underlying normal distribution on the logarithm. For a distribution with $\mu = 0$ and $\sigma = 1$, the mean of the original distribution is 1.65 times the median. In the present study, about 90% of the distributions have means greater than the median, with factors ranging from 1 to about 3. The hypothesis that the data will fit the model of log-normality appears plausible.

The mean(μ)of the underlying normal distribution is the logarithm of the geometric mean (GM) of the original distribution. For this reason, the geometric mean is generally taken to be the more appropriate measure of central tendency for a log-normal distribution. Put another way, if the theory of errors is applied to the underlying (symmetrical) distribution on the logarithm of the quantity being measured, the best estimate is the mean of that distribution. The mean of the underlying distribution corresponds to the geometric mean of the original distribution. The relationship between the two distributions (for the case $\mu = 0$, $\sigma = 1$) is illustrated by Figures 1 and 2.

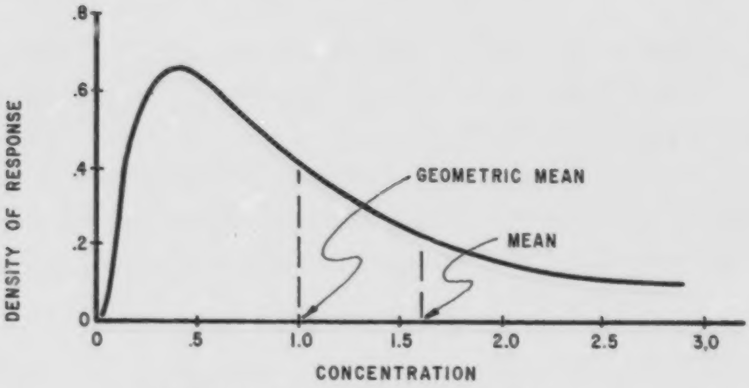

FIGURE I ORIGINAL DISTRIBUTION

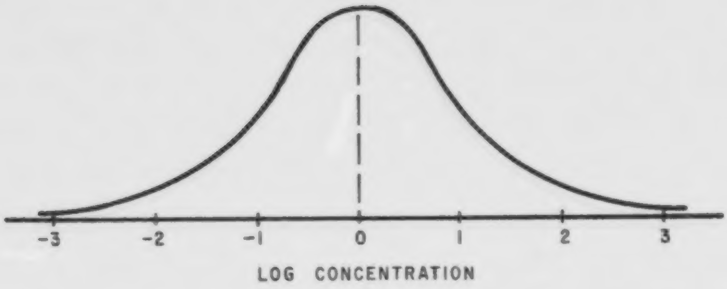

FIGURE 2 UNDERLYING NORMAL DISTRIBUTION

With an exact log-normal distribution, the geometric mean is identical with the median.[11] For applied exercises where the distributions tend to be ragged, the median has the additional advantage that it is less influenced by extreme outlying estimates. In experimental studies, the median has been more accurate than the mean and slightly more accurate than the geometric mean.(Unpublished data available on request from N. Dalkey)

Therefore, the median is used as the measure of central tendency or "best estimate." Since the median is an order statistic, an appropriate measure of dispersion is the interquartile range, i.e., the range around the median that contains 50% of the responses. This is the measure of dispersion that has been used in most applied Delphi studies. Experimental studies have not identified any specific advantages of this statistic (over other forms of feedback, for example).[12]

C. MEASURES OF VALIDITY

Two indices for analysis of validity are used in this study. They are the second round dispersion of the estimates, and self-rating on the part of the panelists. It might be expected a priori that some relationship exists between the dispersion and accuracy. If the Delphi procedure were a sampling process -- i.e., if each estimate were a random sample out of some distribution of estimates, with the true response at the geometric mean of that distribution -- then the error of the observed geometric mean would simply be the sampling error. The sampling error is related to the standard deviation σ of the distribution from which the sample is drawn by the relationship.

$$S.E. \propto \sigma/\sqrt{n}$$

where n is the number of estimates in the sample.[13] Thus, the greater σ the greater the expected error for a given sample size.

However, the process of estimation in a group is not a random sampling out of an unbiased distribution (geometric mean = true answer). In experimental studies with student subjects and general information questions, the error is about three times the sampling error estimated from the standard deviation in Figure 6 of reference 9. In their study using short-range predictions as subject matter, Dalkey and Brown[11] found that the correlation between error and standard deviation was about .67; however, there is no way to guarantee that the numerical relationship between error and standard deviation found in that study generalizes to the present study. The fact that the relationship between error and standard deviation is substantially the same for short-range predictions and general information questions, as observed by Dalkey and Brown,[11] is some ground for expecting the generalization to hold.

The experiments[14] indicate that the bias increases on the second round. The amount of convergence, as indicated by the reduction in standard deviation, between round one and round two is greater than the decrease in error. Numerically, a least squares approximation gives Log Error = $.6\sigma$ for round one, and Log Error = 1.2σ for round 2. Thus a criterion for "good" estimates based on the second round distribution must be more stringent than a criterion based on the first round distribution.

One convenient reference point for applying dispersion as a criterion of validity is afforded by the notion of sufficient agreement discussed in the next section on result feedback. That notion suggests a cut point at an initial log error of about .3. Using the relationship $\text{Log } E = 1.2\sigma$, and rescaling to the original distribution, a criterion of $S = 1/3 \text{ Md}$ is arrived at where S is the observed standard deviation, and Md denotes the median. If the analogy with the short-range prediction data holds, the expected error for estimates fulfilling this criterion would be less than 33% of the median.

The other internal criterion of validity, namely the self-rating, is obtained by asking each panelist to rate each of his estimates on a scale of 1-10, where 1 means "my answer is a sheer guess" and 10 means "I know the answer very well." In previous experiments, correlations between individual self-ratings and individual accuracy is not very high, ranging around .25. However, the correlation between the *average* self-rating and the error of the median was -.62 for the short-range prediction study.

The best criterion of validity for the group estimates obtained in this study is experimental verification. Thus, the finalized data of this study are subjected to both statistical scrutiny and verification with available experimental data.

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* The cut point of 5 for the group self-ratings was based on taking the mid-point of the range.

D. CRITERIA FOR FIRST ROUND RESULT FEEDBACK

The basic reason for the iteration step is the expectation that the error of the median will decrease as a result of reestimation. Experimental studies [8,9,11] have shown that for a majority of the cases, accuracy did increase between round one and round two. Figure 3 shows the results of several of these studies concerning the relationship between round one error, and the change in error between round one and round two. In these experiments, two rounds of estimates were obtained, the second with feedback of the medians and quartiles of the first round answers. The abscissa in Figure 4 is the error of the median for the first round answers. The ordinate is the change in error between first and second rounds. Error is defined here as:

$$E = \ln \frac{Md}{T}$$

Md is the median answer and T the true answer. The vertical bars indicate that the absolute value of the logarithm is taken. Note that E = 0, if Md = T. A positive value for the change (E of round 1 minus E of round 2) indicates the median is more accurate on round 2. As the figure shows, if the initial error is .3 or less, i.e., $\ln \frac{Md}{T} \leq .3$, indicating $.75 = \frac{Md}{T} \leq 1.35$, the effect of iteration is to increase the error on the average. Thus, for questions where the initial error is expected to be small, reestimation is likely to be counterproductive. Since the initial error cannot be measured in practice, the first round standard deviation is the next best indicator. Using the relationship Log E = .6 (for the first round), Log E $\leq$ .3 corresponds to S $\leq$ .6 Md where S is the observed standard deviation. This reference point has been used as a definition of "sufficient agreement" in several previous Delphi studies, where sufficient agreement is taken to mean that it is inappropriate to have the group reestimate.[15]

For the present study, the decision was made to impose a more stringent criterion, primarily on the grounds that the degradation on iteration for modest initial error is small, and some large errors might be greatly reduced. The criterion selected was to feedback the first round results for those with interquartile range greater than one-half of the median.

CHANGE OF GROUP ESTIMATE AS A FUNCTION OF GROUP ERROR

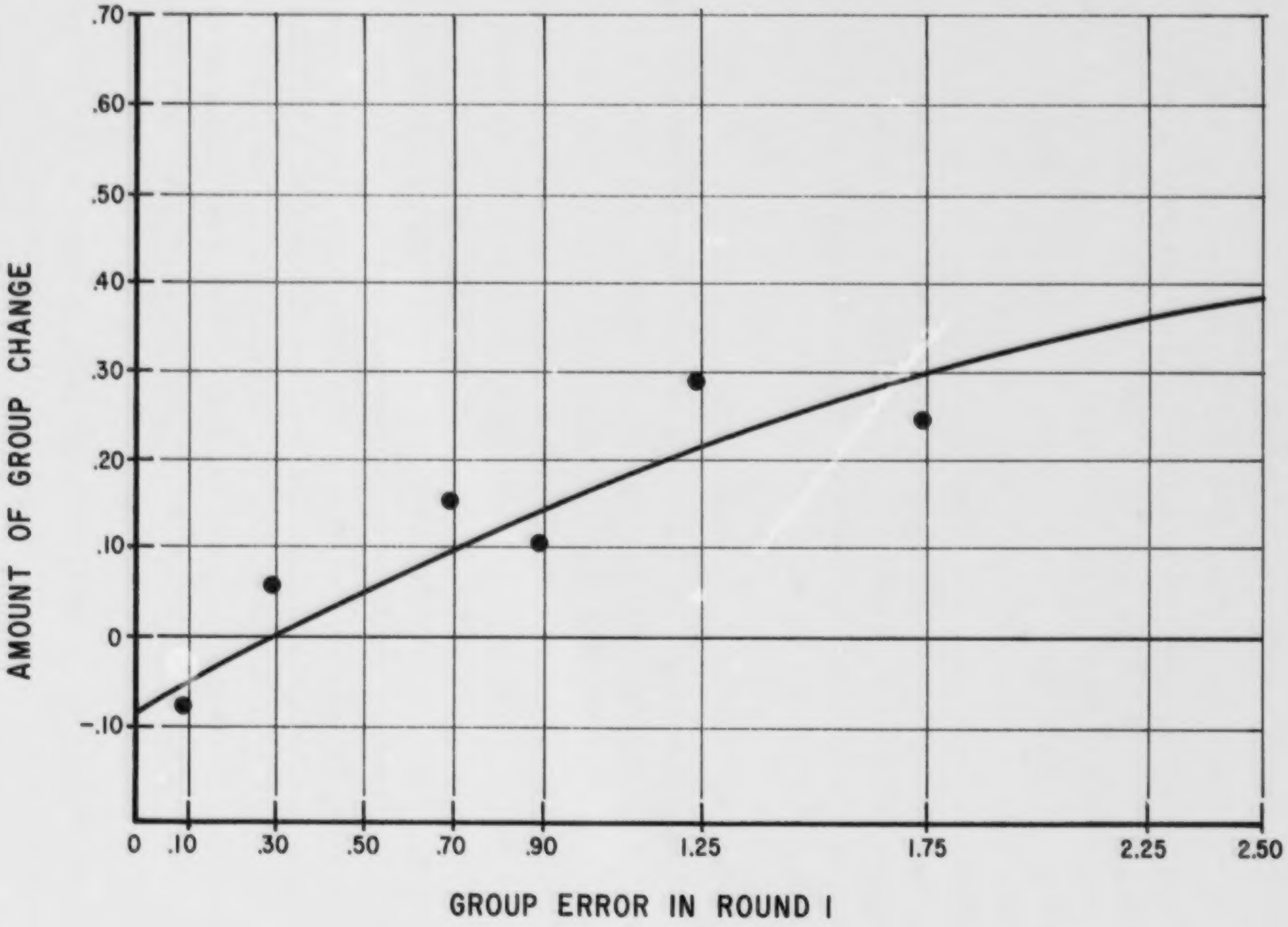

FIGURE 3

E. CONFIDENCE LIMITS

In addition to estimating the one hour exposure at which a given percentage of a given population would experience a given impairment, the panelists were asked to estimate the range within which this estimate might fall. Specifically, they were asked to estimate an upper limit Y_L defined as the dosage at which the panelist felt there was no more than a 5% chance that the dosage would exceed his estimate and a corresponding lower limit Y_U. The medians of the Y_L's and the Y_U's thus represent the group estimates of the confidence range. Although the quartiles for these limits were computed, they were not fed back to prevent overloading the panelists with nine numbers for each dosage estimate. The medians of the best estimate X and its upper and lower quartiles were fed back.

It is emphasized that the distribution of responses and the estimated range should not be confused. Figure 4 schematically shows the relationships involved. The curves in Figure 4 illustrate the distributions of responses for Y_L, X and Y_U, for a given pollutant, a given population type, a given level of impairment and a given percentage of population. For external validity tests -- e.g., comparison of the panel estimates with experimental data, the relevant estimates are the medians of Y_L, X, and Y_U. Thus, if the experimental data falls well within the estimated range, this is a positive outcome for the study. If the experimental data falls outside the estimated range, this is a negative outcome. Inspection of the data indicate that there is a fairly close relationship between the interquartile ranges on X and the estimated range, with the latter somewhat wider than the former for oxidant and NO_2. For CO, Y_L is generally lower than Q_{25} for X, but Y_U is generally lower than Q_{75} for X.

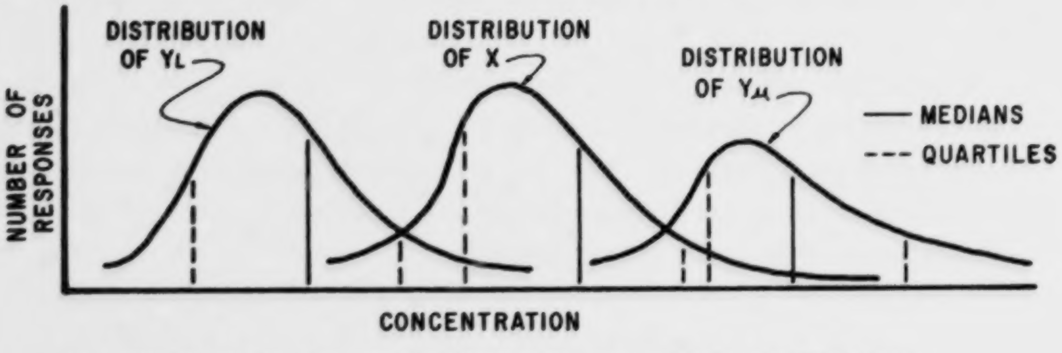

ILLUSTRATION OF DISTRIBUTIONS ON RANGE ESTIMATES

FIGURE -4-

F. THE QUESTIONNAIRE

The questionnaire was designed to allow a group of experts to estimate one hour concentrations of oxidant, nitrogen dioxide, or carbon monoxide which would induce specific functional abnormalities in population categories of healthy individuals and of ones with underlying disease states. Because children, adults, and the old age may differ in their response to air pollutant exposures, the questionnaire querried the effect of air pollution in normal members of each age group.

The underlying illnesses selected for evaluation were ones that might be expected to enhance sensitivity to specific air pollutants. Since oxidant air contaminants (ozone and nitrogen dioxide) primarily impair respiratory function,[2-3] the experts were asked to estimate the dose-response relationships for population categories of individuals with asthma, hay fever-sinusitis, influenza, acute viral bronchitis, upper respiratory infection, acute bacterial pneumonia, mild chronic obstructive lung disease, severe chronic obstructive lung disease, and chronic respiratory disease of a noninfectious nature such as pneumoconiosis or sarcoidosis. The experts were also asked to estimate the effect of oxidant and nitrogen dioxide for patients with mild or severe heart conditions. These categories were included because the intimate relationship of respiratory to cardiac function suggests that injury to the former system might reflect itself in an indirect fashion by decreasing cardiac function.

The deleterious effects of carbon monoxide are due to the formation of carboxyhemoglobin with a resultant decrease in the oxygen carrying capacity of the blood.[4] Patients with underlying cardiac disease comprised the principle population groups of interest as patients with these conditions may be unusually sensitive to diminshed oxygenation. Estimates of carbon monoxide toxicity were obtained for the aforementioned respiratory diseases to determine if in the opinion of the experts these conditions also might increase sensitivity to carbon monoxide.

Abnormalities incurred by exposure to each air pollutant were specified for each population category. In many instances, clinical studies had shown that exposure to air pollutants might induce or enhance the presence of the abnormality. With some abnormalities, such as the occurrence of nasal or sinus drainage in hay fever or sinusitis, this relationship is not known and therefore it is conceivable that this untoward effect might not result from pollutant exposure. Dose-response relationships in circumstances such as this must be considered problematical, until experimental data become available.

The abnormalities were arbitrarily divided into categories (discomfort, disability, and incapacity) in accordance with the probable severity of the abnormalities for the majority of patients in each population category. It must be emphasized that these divisions are inexact and that it is likely that abnormalities such as dyspnea or headache may be discomforting for some individuals and disabling for others. The virtue of the scale is that it allows assessments of dose-response which correlate with clinical parameters of increasing importance. As an example, for the population category Acute Bacterial Pneumonia, cough was considered discomfort, a minimal effect, dyspnea was considered disability, a more serious consequence, and acute respiratory failure was considered incapacity, a much more severe medical disturbance.

Since the biologic effect of a pollutant varies with the duration of exposure at a fixed concentration, a fixed time period of one hour was chosen in order to minimize this factor and to allow comparison of individual pollutant effects. Longer exposure periods might have been chosen, but these would have increased the difficulty in estimating the dose-response relationship without improving the precision of the estimate.

The population varies significantly in their response to a given pollutant exposure independent of the health status of the group.[1-2] The questionnaire considered this intrinsic variation by querying the concentration at which 90%, 50%, 10%, and 0% of the population would be expected to manifest the stated abnormality. In addition to estimating these points, the experts indicated a range of pollutant concentrations for each dose-response result to allow limits to be calculated for each estimate. The expert also estimated the duration in hours of the abnormalities. Self-ratings were given for each set of three answers -- the range Y_L, Y_U, and the best estimate X.

A complete set of the questionnaire for the study is included in Appendix A, pages 85-131. Definition of each population group, the normal individual as well as those with underlying disease, and examples of symptoms expected under each category of abnormalities (discomfort, disability, and incapacity) are presented in details in the questionnaire of Appendix A and summarized in Tables 4-5.

TABLE 4: Population Categories Which May be Affected,
Definition of Conditions for Incapacity, Disability and Discomfort
Photochemical Oxidant and Nitrogen Dioxide

Population Category	Definition of Conditions		
	Incapacity	Disability	Discomfort
Normal	May precipitate respiratory and cardiac problems, bronchopneumonia	Headache	Eye irritation; non-productive coughing, chest tightness
Children*	"	"	"
Old Age*	Acute respiratory failure	Bronchitis	Dyspnea
Heart Condition, Mild*	Pulmonary edema	Congestive heart failure	"
Heart Condition, Severe*	Angina or myocardial infarction	Pulmonary edema	Worsening congestive heart failure
Hay Fever, Sinusitis	Nasal or sinus drainage and headache	Nasal or sinus drainage	Nasal or sinus discomfort
Influenza	Superimposed bacterial pneumonia	Dyspnea	Increased cough and pleuritic pain
Upper Respiratory Infection	Superimposed bacterial infection	Dyspnea, or need medication and rest	Worsening symptoms
Asthma	Status asthmaticus	Asthmatic attack	Dyspnea
Acute Viral Bronchitis	Acute respiratory failure	Onset or worsening of dyspnea	Worsening of cough
Acute Bacterial Pneumonia	"	"	"
Chronic Respiratory Diseases*	Pneumonia	Respiratory infection	Dyspnea
Mild Chronic Obstructive Lung Disease*	Broncho-pneumonia, cor pulmonale	Exacerbation of bronchitis, fever and increased sputum production and chest pain	"
Severe Chronic Obstructive Lung Disease*	"	"	"

* Please refer to Appendix A for further explanation.

TABLE 5: Population Categories Which May be Affected, Definition of Conditions for Incapacity, Disability and Discomfort Carbon Monoxide

Population Category	Definition of Conditions		
	Incapacity	Disability	Discomfort
Normal	Coma or convulsions	Throbbing headache, confusion, irritability, dizziness	Mild headache, errors in cognitive function
Children*	"	"	"
Old Age*	"	"	"
Hay Fever, Sinusitis	"	"	"
Upper Respiratory Infection	"	"	"
Asthma	Asthmatic attack, coma, convulsion	"	"
Heart Condition, Mild*	Angina pectoris, arrythmia, coma or convulsions	Throbbing headache, confusion, irritability, dizziness, and increases in dyspnea	"
Heart Condition, Severe*	"	"	"
Influenza	Respiratory failure, coma, convulsions	"	"
Acute Viral Bronchitis	"	"	"
Acute Bacterial Pneumonia	"	"	"
Chronic Respiratory Diseases*	"	"	"
Severe Chronic Obstructive Pulmonary Disease*	"	"	"
Mild Chronic Obstructive Pulmonary Disease*	"	Throbbing headache, confusion, irritability, dizziness	"

* Please refer to Appendix A for further explanation.

SECTION 6

RESULTS

Basing on the raw data obtained from the second round survey, median estimates, first and third quartiles, mean and standard deviations for each polulation fraction were computed. Using the median estimates to fit into the logistic distribution model (See pages 51-60), dose-response curves for each abnormality affecting different fraction of various population categories by each pollutant were plotted. These dose-response curves for the second round are presented in Appendix B. The raw data and dose-response curves for the first round and raw data for the second round are not included in this report. Limited copies of these data are available from the principal investigator upon request.

A summary showing the first round results on the median estimates for discomfort, disability and incapacity affecting different fraction of various population categories by each pollutant is given in Tables 6-17. These tables also include the time duration of each abnormality caused by the pollutant exposure, and the panelists' self-confidence ratings.

The first round data were analyzed for group agreement with the feedback criterion outlined in page 17. Those answers with interquartile range greater than one-half of the median were fed back to the panel members for reestimation. Using the feedback criterion, good group agreement was observed in 38% of the answers for the photochemical oxidant questionnaire, 10% for carbon monoxide, and 1% for nitrogen dioxide. On this stringent criterion, two-thirds of the estimates for oxidant, about 90% of the estimates for CO, and all of the estimates for NO_2 were iterated. Estimates with good agreement and not iterated in the second round were identified with asterisk (*) in Tables 6-17.

The other criterion for validity measurement used in the study was self-confidence rating. Each panelist was asked to rate each of his estimates on a scale of 1-10, where 1 meant "the answer is a sheer guess," and 10 meant "the panelist knows the answer very well." An average self-rating of 5 or higher was used as the cut-off point for acceptable confidence score. Based on this self-rating system, panel members put higher confidence in their answers for photochemical oxidant and carbon monoxide questionnaires than those for nitrogen dioxide. In about 50% of their answers for both the photochemical oxidants and carbon monoxide questionnaires, the panel members gave an average self-rating score of 5 or higher, while they showed the same degree of confidence in about 25% of their answers for nitrogen dioxide.

The second round results were summarized in Tables 18-29. These tables include all new estimates from the panelists as well as those first round data with good group agreement and not required reiteration. This data represents the improved and finalized data for the study.

A different criterion was used to evaluate the degree of agreement within the group on answers in the second round. The estimate is considered to have good group agreement if its standard deviation is equal to or less than one-third of the median value. Based on this criterion, good agreement is observed in 58%, 17% and 8% of answers for the photochemical oxidants, carbon monoxide and nitrogen dioxide questionnaires, respectively. Comparing to the first round data, there is a definite improvement in group agreement in the second round. It must be noted, however, a different criterion for assessing group agreement was used in the first round survey.

TABLE 6: Estimates of Effects on 0% of Population by Population Category, Photochemical Oxidant Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	0.22	0.35	0.50		6.0	0.10	0.20	0.40		5.5	0.03	0.10	0.20		6.0
Children	0.20	0.30	0.45		4.0	0.10	0.20	0.40		4.0	0.00	0.10	0.20		5.5
Old Age	0.20	0.32	0.42		4.0	0.10	0.20*	0.30		4.5	0.00	0.10	0.20		5.0
Heart Condition, Severe	0.20	0.30*	0.40		4.0	0.10	0.27	0.40		4.0	0.03	0.10	0.20		4.5
Heart Condition, Mild	0.20	0.35*	0.50		4.0	0.10	0.23*	0.35		4.0	0.03	0.10	0.20		5.0
Hay Fever, Sinusitis	0.13	0.27	0.40		4.0	0.10	0.20	0.35		4.0	0.00	0.10	0.20		5.0
Upper Respiratory Infection	0.13	0.30	0.45		5.0	0.10	0.20*	0.35		4.5	0.00	0.10*	0.20		5.0
Asthma	0.13	0.30	0.50		5.0	0.10	0.20*	0.30		5.0	0.00	0.10*	0.20		5.0
Viral Bronchitis	0.10	0.30	0.50		3.0	0.08	0.20	0.35		3.5	0.00	0.10*	0.20		4.5
Bacterial Pneumonia	0.15	0.30	0.50		4.5	0.10	0.20	0.40		4.0	0.00	0.10*	0.20		4.5
Influenza	0.15	0.30	0.42		5.0	0.10	0.20	0.35		5.5	0.05	0.10	0.20		5.0
Chronic Respiratory Disease	0.20	0.30*	0.55		4.5	0.10	0.20*	0.40		4.5	0.00	0.10*	0.20		5.0
Mild Chronic Obstructive Disease	0.20	0.32	0.47		4.0	0.08	0.20	0.35		5.0	0.00	0.10	0.23		5.5
Severe Chronic Obstructive Disease	0.10	0.20	0.35		4.5	0.05	0.15*	0.23		5.0	0.00	0.10*	0.20		5.0

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 7: Estimates of Effects on 10% of Population by Population Category, Photochemical Oxidant Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	0.55	0.75*	1.10	19	6.0	0.40	0.50*	0.80	7	6.0	0.14	0.30	0.50	4	6.0
Children	0.55	0.75*	1.00	24	4.0	0.35	0.50*	0.80	7	4.5	0.20	0.35	0.50	3	5.5
Old Age	0.42	0.67	0.93	24	4.0	0.30	0.42	0.70	12	4.0	0.20	0.30*	0.50	6	5.0
Heart Condition, Severe	0.40	0.60*	0.80	24	4.0	0.40	0.55	0.80	18	4.0	0.20	0.40	0.55	24	4.5
Heart Condition, Mild	0.47	0.80	1.05	24	4.0	0.35	0.60	0.90	12	4.0	0.20	0.40*	0.50	6	4.5
Hay Fever, Sinusitis	0.40	0.60	0.95	14	4.5	0.30	0.50	0.70	11	5.0	0.15	0.30	0.43	7	5.0
Upper Respiratory Infection	0.40	0.60	0.90	24	5.0	0.30	0.45	0.75	11	5.0	0.15	0.35*	0.50	9	5.0
Asthma	0.40	0.65	0.80	18	5.0	0.23	0.40	0.60	9	5.0	0.10	0.30	0.50	6	5.0
Viral Bronchitis	0.40	0.60*	0.95	24	3.5	0.27	0.40*	0.65	12	4.0	0.10	0.30	0.50	10	3.5
Bacterial Pneumonia	0.42	0.75*	1.00	24	3.5	0.30	0.45	0.70	12	4.5	0.10	0.30	0.45	11	4.5
Influenza	0.40	0.60	1.00	24	4.5	0.30	0.40*	0.70	9	5.5	0.15	0.35*	0.50	6	5.0
Chronic Respiratory Disease	0.40	0.60	1.05	24	4.0	0.35	0.50	0.80	24	4.0	0.20	0.30	0.45	8	5.0
Mild Chronic Obstructive Disease	0.40	0.80	1.05	24	4.0	0.25	0.45	0.80	24	5.0	0.10	0.30	0.50	9	5.0
Severe Chronic Obstructive Disease	0.30	0.50	0.70	24	5.0	0.15	0.40	0.55	24	5.5	0.10	0.25	0.45	7	5.0

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 8: Estimates of Effects on 50% of Population by Population Category, Photochemical Oxidant Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	0.75	1.10*	1.40	13	5.5	0.50	0.80	1.15	7	5.5	0.35	0.60*	0.80	4	6.0
Children	0.75	0.95	1.30	24	4.0	0.50	0.70*	1.15	7	4.5	0.35	0.60*	0.75	4	4.0
Old Age	0.80	1.00*	1.30	24	4.0	0.47	0.75*	1.00	12	4.0	0.30	0.50	0.65	6	4.5
Heart Condition, Severe	0.65	0.95	1.35	24	4.5	0.50	0.75	1.05	18	4.0	0.35	0.50	0.70	24	4.5
Heart Condition, Mild	0.75	1.00	1.50	24	4.0	0.45	0.75	1.15	14	4.0	0.35	0.50*	0.65	6	4.5
Hay Fever, Sinusitis	0.55	0.80	1.10	12	5.0	0.45	0.70	0.95	11	4.5	0.25	0.40	0.65	7	5.0
Upper Respiratory Infection	0.70	0.90	1.15	24	5.0	0.45	0.65	0.85	11	5.0	0.30	0.50	0.70	9	5.0
Asthma	0.60	0.90	1.20	18	5.0	0.45	0.70	0.95	9	5.0	0.30	0.45	0.65	6	5.0
Viral Bronchitis	0.60	0.85*	1.20	24	5.0	0.40	0.60*	0.80	12	4.5	0.20	0.40	0.75	10	5.0
Bacterial Pneumonia	0.65	0.92*	1.30	24	4.5	0.35	0.60	0.85	12	4.0	0.25	0.45	0.70	11	4.0
Influenza	0.60	0.85	1.10	24	5.0	0.40	0.60	0.75	9	5.0	0.25	0.40	0.70	6	5.0
Chronic Respiratory Disease	0.80	1.05	1.40	24	5.0	0.45	0.70*	1.00	24	4.0	0.30	0.50*	0.60	8	5.0
Mild Chronic Obstructive Disease	0.75	1.10	1.50	24	4.0	0.50	0.80	1.20	24	5.0	0.30	0.50	0.75	10	5.0
Severe Chronic Obstructive Disease	0.50	0.65	0.80	24	5.0	0.35	0.55	0.75	24	5.0	0.20	0.40	0.55	10	5.0

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 9: Estimates of Effects on 90% of Population by Population Category, Photochemical Oxidant Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	1.15	1.50*	1.80	20	4.0	0.80	1.00*	1.40	7	4.5	0.45	0.80*	1.00	4	6.0
Children	1.10	1.40*	1.60	24	3.5	0.70	1.00*	1.20	7	4.0	0.55	0.75*	1.00	4	4.5
Old Age	1.00	1.40*	1.65	24	5.0	0.70	1.00*	1.40	12	5.0	0.40	0.70*	0.95	6	5.0
Heart Condition, Severe	1.00	1.20	1.85	24	4.5	0.80	1.00*	1.40	18	3.5	0.50	0.75*	1.00	24	4.0
Heart Condition, Mild	1.00	1.45*	2.00	24	4.0	0.75	1.15*	1.65	24	4.0	0.45	0.70*	0.90	6	4.5
Hay Fever, Sinusitis	0.75	1.00	1.30	12	4.5	0.55	0.80	1.10	11	4.5	0.30	0.55	0.75	8	5.5
Upper Respiratory Infection	0.80	1.20	1.45	24	5.0	0.80	0.95	1.10	9	5.0	0.50	0.70	0.95	9	5.0
Asthma	0.80	1.10	1.50	18	5.0	0.70	0.95	1.20	9	6.0	0.32	0.55	0.85	6	5.5
Viral Bronchitis	0.95	1.25	1.75	24	5.0	0.55	0.80*	1.05	12	4.5	0.30	0.60*	0.85	10	5.0
Bacterial Pneumonia	0.90	1.20*	1.65	24	5.0	0.50	0.80*	1.05	12	4.5	0.30	0.55*	0.85	11	4.5
Influenza	0.80	1.00*	1.40	36	5.0	0.60	0.80	1.00	9	5.5	0.40	0.60	0.80	6	5.0
Chronic Respiratory Disease	1.00	1.45*	1.80	24	5.0	0.75	1.05	1.40	24	5.0	0.40	0.60*	0.85	9	5.0
Mild Chronic Obstructive Disease	1.00	1.35	1.85	24	4.5	0.60	0.95*	1.35	24	5.0	0.40	0.60*	0.95	10	5.0
Severe Chronic Obstructive Disease	0.60	1.00	1.35	24	5.5	0.45	0.60	0.80	24	6.0	0.25	0.45	0.65	10	5.5

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 10: Estimates of Effects on 0% of Population by Population Category,
Nitrogen Dioxide Concentrations (ppm),
First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	1.35	2.25	3.00		6.0	1.00	1.85	2.50		5.0	0.20	0.80	1.75		5.5
Children	1.00	2.00	3.00		4.5	0.75	1.25	2.00		3.5	0.20	0.50	1.50		4.5
Old Age	1.00	2.25	3.00		4.0	0.50	1.25	2.75		4.0	0.20	0.55	1.50		5.0
Heart Condition, Severe	1.00	1.75	2.75		4.0	0.50	1.10	2.10		4.0	0.15	0.80	1.25		4.0
Heart Condition, Mild	1.00	2.00	3.25		5.0	0.50	1.15	2.50		5.0	0.20	0.75	1.65		5.0
Hay Fever, Sinusitis	1.75	2.50	3.25		3.5	0.85	1.65	2.50		4.5	0.25	1.00	1.75		5.0
Upper Respiratory Infection	0.90	2.00	3.00		3.2	0.50	1.10	2.50		3.5	0.20	1.00	2.00		4.5
Asthma	1.20	2.10	3.50		3.0	0.45	1.30	2.65		3.5	0.20	0.75	1.75		4.0
Viral Bronchitis	0.901	2.00	3.35		3.0	0.45	1.10	2.10		3.5	0.40	1.00	1.80		4.0
Bacterial Pneumonia	1.00	2.00	2.90		3.0	0.45	1.00	2.00		4.5	0.35	1.00	1.55		4.0
Influenza	1.50	2.35	3.25		3.5	0.75	1.40	2.65		4.5	0.20	1.00	2.00		4.5
Chronic Respiratory Disease	0.65	2.25	3.10		4.0	0.50	1.25	2.50		3.5	0.20	0.75	1.75		4.5
Mild Chronic Obstructive Disease	1.00	2.15	3.50		3.5	0.50	1.65	2.90		3.5	0.25	1.00	1.90		4.5
Severe Chronic Obstructive Disease	0.55	1.50	2.55		3.0	0.45	1.00	2.05		3.5	0.15	0.55	1.50		3.5

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 11: Estimates of Effects on 10% of Population by Population Category, Nitrogen Dioxide Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	2.45	4.00	5.55	12	5.5	1.80	3.00	4.50	6	4.5	1.00	2.00	3.00	5	6.0
Children	2.10	3.80	4.90	12	5.0	1.15	2.50	3.75	6	3.0	0.75	1.75	3.00	4	5.0
Old Age	2.10	4.00	5.50	24	4.5	1.00	3.00	4.55	18	4.5	0.50	1.75	3.00	7	5.0
Heart Condition, Severe	2.00	3.75	5.00	24	3.5	1.50	2.70	4.15	24	3.5	0.85	2.00	3.25	12	4.0
Heart Condition, Mild	2.00	3.85	5.10	24	5.0	1.75	3.00	4.25	24	5.0	0.50	1.75	3.25	7	5.0
Hay Fever, Sinusitis	3.00	4.25	5.25	12	3.0	2.00	3.00	4.35	8	3.0	1.00	2.50	3.75	6	3.5
Upper Respiratory Infection	2.50	3.25	4.50	24	4.5	1.45	2.65	4.00	12	3.0	1.00	2.20	3.25	6	5.0
Asthma	2.30	4.00	5.00	24	4.0	1.50	3.00	4.40	11	3.5	1.00	2.00	3.00	5	3.5
Viral Bronchitis	2.55	3.75	4.95	24	4.0	1.30	2.25	3.80	12	4.5	0.90	1.80	3.10	10	4.0
Bacterial Pneumonia	1.80	2.85	4.75	24	4.5	1.45	2.05	3.00	12	4.5	1.00	1.70	2.90	10	3.5
Influenza	2.30	3.75	5.00	24	3.5	1.65	2.75	4.20	12	3.0	1.00	2.25	3.75	7	3.5
Chronic Respiratory Disease	2.35	3.65	4.95	24	4.0	1.40	2.50	4.00	24	4.0	1.00	2.00	3.00	8	4.0
Mild Chronic Obstructive Disease	2.05	4.00*	5.25	24	4.0	1.50	2.85	4.60	21	4.0	1.00	2.00	3.25	6	4.0
Severe Chronic Obstructive Disease	1.80	3.50	4.75	24	4.0	1.40	2.40	4.00	21	4.0	1.00	1.60	2.80	10	4.0

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 12: Estimates of Effects on 50% of Population by Population Category, Nitrogen Dioxide Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Tu	T	R	Yl	X	Yu	T	R
Normal	3.90	5.75	8.00	12	5.5	3.30	4.50	5.25	6	5.0	1.90	3.75	4.25	3	6.0
Children	2.80	5.00	6.15	12	5.0	2.20	3.50	4.50	6	3.5	1.50	2.75	3.50	4	5.0
Old Age	3.75	5.00	7.10	24	4.5	2.00	4.10	5.75	18	4.5	1.00	2.50	3.25	7	5.5
Heart Condition, Severe	3.30	5.00	5.90	24	3.5	2.45	3.85	5.25	24	3.5	1.75	2.70	3.50	12	4.0
Heart Condition, Mild	3.00	4.65	6.30	24	5.0	2.00	4.35	5.65	24	5.0	1.50	2.75	3.50	10	5.5
Hay Fever, Sinusitis	2.80	4.75	6.30	12	3.0	2.75	4.50	5.55	8	3.0	2.30	3.25	4.10	6	3.5
Upper Respiratory Infection	3.55	4.75	5.50	24	4.5	2.00	3.00	4.75	12	3.5	1.75	3.00	4.25	7	5.0
Asthma	3.50	5.00	7.70	24	3.5	2.20	4.25	5.30	11	3.5	1.75	2.50	4.25	5	3.5
Viral Bronchitis	3.50	4.75	5.75	24	4.0	1.75	3.00	5.00	12	4.5	1.10	2.00	3.25	10	4.0
Bacterial Pneumonia	3.50	4.35	5.25	24	4.0	1.50	2.70	4.10	12	4.0	1.25	2.10	3.55	10	3.5
Influenza	3.55	4.75	5.95	24	3.5	2.20	3.50	5.00	12	3.5	1.75	2.75	4.00	8	3.5
Chronic Respiratory Disease	3.15	4.40	5.75	24	4.0	1.50	2.80	5.00	24	4.0	1.00	2.25	3.25	8	4.5
Mild Chronic Obstructive Disease	3.30	5.00	6.20	24	4.0	2.15	4.00	5.35	21	4.0	1.50	2.25	3.75	8	4.0
Severe Chronic Obstructive Disease	3.00	4.50	5.75	24	4.0	1.65	3.00	4.75	21	4.0	1.25	2.00	3.35	10	4.0

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range $\leq \frac{1}{2}$ of Median)

TABLE 13: Estimates of Effects on 90% of Population by Population Category, Nitrogen Dioxide Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	5.00	6.25	9.00	12	5.5	4.00	5.50	7.00	6	5.0	3.50	4.75	5.75	3	6.5
Children	3.50	6.25	7.50	12	5.0	3.00	5.00	6.75	6	5.0	2.30	3.50	4.25	4	5.5
Old Age	4.00	6.00	9.00	24	4.5	2.50	5.00	6.25	18	4.0	2.00	3.50	4.75	7	5.0
Heart Condition, Severe	4.50	6.50	7.50	24	4.0	2.75	5.00	6.00	24	3.5	2.25	3.60	4.75	21	3.5
Heart Condition, Mild	4.25	6.50	7.75	24	5.5	3.50	5.00	5.25	24	5.0	2.50	4.25	5.00	10	5.0
Hay Fever, Sinusitis	4.75	5.75	7.00	12	4.0	3.00	5.00	6.75	8	4.5	2.80	4.75	5.60	6	5.0
Upper Respiratory Infection	4.50	6.00	7.50	24	5.0	2.75	4.50	5.50	12	4.5	2.30	4.00	5.00	7	5.0
Asthma	5.25	6.50	8.00	24	4.0	4.50	5.00	6.00	11	4.0	2.50	3.00	4.80	5	4.0
Viral Bronchitis	4.75	6.00	7.25	24	4.5	3.00	4.00	5.50	12	4.5	2.30	3.25	4.10	10	4.5
Bacterial Pneumonia	5.25	6.50	7.25	24	4.5	1.85	3.00	4.95	12	4.5	1.45	3.00	4.50	10	4.0
Influenza	4.50	5.75	8.00	24	4.5	2.50	4.50	6.25	12	4.5	2.05	3.50	4.75	10	4.0
Chronic Respiratory Disease	4.75	6.00	7.50	24	4.0	2.50	4.25	5.50	24	4.0	1.75	3.00	4.70	8	4.0
Mild Chronic Obstructive Disease	4.30	6.00	8.50	24	4.0	2.60	5.00	6.50	21	4.0	1.75	2.75	4.90	8	4.0
Severe Chronic Obstructive Disease	4.00	5.50	7.25	24	4.0	2.15	3.85	5.55	21	4.0	1.60	2.75	4.40	10	4.0

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 14: Estimates of Effects on 0% of Population by Population Category,
Carbon Monoxide Concentrations (ppm),
First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	60.0	80.0	130.0		5.0	40.0	60.0	80.0		5.5	20.0	35.0	55.0		6.0
Children	60.0	90.0	145.0		5.5	40.0	60.0	90.0		5.5	14.5	28.0	45.0		6.0
Old Age	60.0	90.0	145.0		5.0	45.0	60.0	90.0		4.5	16.0	32.5	65.0		4.5
Heart Condition, Severe	40.0	55.0	70.0		4.5	25.0	40.0	60.0		4.0	10.0	20.0	42.5		3.5
Heart Condition, Mild	45.0	75.0	100.0		5.0	35.0	55.0	90.0		4.5	22.0	33.5	60.0		4.0
Hay Fever, Sinusitis	60.0	90.0	135.0		4.5	40.0	60.0	80.0		4.5	20.0	35.0	55.0		5.0
Upper Respiratory Infection	60.0	100.0	145.0		4.5	40.0	55.0	80.0		4.5	17.5	32.5	55.0		5.0
Asthma	56.0	100.0	145.0		5.0	35.0	55.0	80.0		4.5	10.0	27.5	45.0		5.0
Viral Bronchitis	55.0	100.0	152.5		5.0	35.0	55.0	80.0		5.0	16.5	30.0	57.5		5.0
Bacterial Pneumonia	60.0	95.0	130.0		4.5	30.0	50.0	80.0		4.0	10.0	21.0	43.5		4.0
Influenza	60.0	100.0	152.5		4.5	25.0	50.0	80.0		4.5	10.0	22.5	45.0		5.0
Chronic Respiratory Disease	60.0	90.0	152.5		4.5	30.0	55.0	80.0		4.0	15.0	28.5	35.0		4.0
Mild Chronic Obstructive Disease	55.0	100.0	145.0		5.0	30.0	55.0	80.0		4.5	10.0	20.0	40.0		4.0
Severe Chronic Obstructive Disease	39.0	80.0	126.0		5.0	20.0	35.0	52.5		3.5	7.5	18.5	30.0		3.5

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 15: Estimates of Effects on 10% of Population by Population Category, Carbon Monoxide Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	160.0	200.0	222.5	12	5.5	100.0	132.5	177.5	7	5.5	55.0	75.0	100.0	3	6.0
Children	155.0	190.0	227.5	12	5.0	80.0	125.0	176.0	7	5.0	44.0	75.0	95.0	3	5.0
Old Age	150.0	177.5	200.0	12	5.5	90.0	125.0	172.5	7	4.5	49.0	75.0	106.0	4	4.0
Heart Condition, Severe	55.0	100.0*	140.0	24	4.5	54.0	80.0	120.0	16	5.0	33.0	60.0	82.0	5	4.5
Heart Condition, Mild	120.0	155.0*	195.0	12	5.0	90.0	120.0	160.0	12	4.5	45.0	85.0	111.0	5	4.5
Hay Fever, Sinusitis	160.0	190.0	232.5	12	4.0	90.0	135.0	170.0	7	3.5	55.0	75.0	100.0	3	3.5
Upper Respiratory Infection	150.0	180.0	230.0	12	4.0	90.0	135.0*	180.0	7	3.5	55.0	75.0	100.0	4	4.0
Asthma	150.0	182.5	235.0	12	4.5	90.0	130.0	180.0	7	4.0	40.0	65.0	90.0	4	4.5
Viral Bronchitis	150.0	175.0	220.0	12	4.5	75.0	120.0*	170.0	7	4.0	40.0	70.0	95.0	4	4.5
Bacterial Pneumonia	130.0	160.0	220.0	12	4.5	60.0	110.0	145.0	9	4.0	32.5	60.0	82.0	5	4.0
Influenza	150.0	184.0	232.5	18	4.0	70.0	125.0	170.0	9	3.5	40.0	70.0	100.0	5	3.5
Chronic Respiratory Disease	150.0	175.0	212.5	12	4.5	80.0	120.0*	160.0	11	4.0	39.0	75.0	100.0	6	3.5
Mild Chronic Obstructive Disease	145.0	175.0	210.0	12	5.0	90.0	130.0	175.0	11	4.5	30.0	60.0	90.0	6	4.5
Severe Chronic Obstructive Disease	97.0	145.0	198.0	24	5.0	50.0	100.0	130.0	13	4.5	25.0	40.0	65.0	6	4.5

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 16: Estimates of Effects on 50% of Population by Population Category, Carbon Monoxide Concentrations (ppm) First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	210.0	260.0	287.5	18	6.5	140.0	170.0	200.0	7	6.0	87.5	120.0	135.0	3	6.5
Children	192.5	235.0	272.5	12	6.0	125.0	165.0*	200.0	7	5.5	73.5	112.5	138.5	3	5.0
Old Age	180.0	210.0	285.0	12	6.0	125.0	165.0	190.0	7	5.0	71.0	102.5	140.0	4	3.5
Heart Condition, Severe	104.0	161.0*	205.0	24	5.0	77.5	122.5	175.0	22	5.5	57.5	80.0	105.0	5	5.5
Heart Condition, Mild	155.0	180.0*	205.0	12	6.0	100.0	152.5	172.5	12	5.0	65.0	102.5	140.0	6	4.5
Hay Fever, Sinusitis	185.0	230.0	300.0	12	5.5	125.0	180.0*	200.0	7	5.0	83.5	120.0	145.0	3	5.5
Upper Respiratory Infection	190.0	220.0	270.0	12	5.0	122.5	175.0*	200.0	7	4.5	72.5	110.0	135.0	4	5.0
Asthma	190.0	235.0	295.0	17	5.5	125.0	172.5*	200.0	10	4.5	65.0	100.0	130.0	5	5.0
Viral Bronchitis	187.5	220.0	247.5	12	5.5	123.5	155.0	190.0	7	4.5	65.0	95.0	124.5	4	5.0
Bacterial Pneumonia	170.0	210.0	225.0	18	5.5	110.0	155.0	200.0	9	4.5	55.0	90.0	120.0	5	4.0
Influenza	190.0	220.0	270.0	18	4.5	122.5	175.0	200.0	9	4.5	60.0	90.0	130.0	5	4.5
Chronic Respiratory Disease	190.0	230.0	265.0	18	5.0	125.0	160.0	196.5	11	4.5	62.5	100.0	132.5	6	4.0
Mild Chronic Obstructive Disease	190.0	230.0	265.0	18	5.0	135.0	170.0	197.5	11	5.0	50.0	85.0	127.5	6	4.5
Severe Chronic Obstructive Disease	145.0	180.0	200.0	24	6.0	84.5	150.0	188.0	13	5.5	45.0	70.0	97.5	6	5.0

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 17: Estimates of Effects on 90% of Population by Population Category, Carbon Monoxide Concentrations (ppm), First Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	235.0	275.0	325.0	16	7.0	160.0	190.0	235.0	10	7.0	114.0	135.0*	155.0	4	6.5
Children	225.0	275.0	325.0	12	7.0	165.0	190.0	235.0	10	7.0	98.0	125.0*	152.5	4	5.5
Old Age	215.0	250.0	300.0	12	6.5	150.0	175.0	200.0	10	5.0	98.0	127.5	157.5	5	5.0
Heart Condition, Severe	130.0	172.5	215.0	25	5.0	100.0	150.0	200.0	24	5.5	75.0	95.0	120.0	5	5.5
Heart Condition, Mild	185.0	200.0	235.0	12	6.0	140.0	165.0	190.0	12	5.0	91.0	129.0	170.0	6	5.0
Hay Fever, Sinusitis	215.0	260.0	300.0	12	6.5	150.0	175.0	215.0	10	5.5	114.0	135.0*	158.5	5	5.0
Upper Respiratory Infection	210.0	250.0	285.0	12	5.5	140.0	175.0	230.0	10	4.5	109.0	140.0*	182.5	5	4.0
Asthma	227.5	262.5	322.5	16	5.5	160.0	187.5	200.0	8	4.0	97.5	130.0*	157.5	5	4.0
Viral Bronchitis	210.0	237.5	272.5	12	5.5	140.0	170.0	200.0	10	4.5	95.0	115.0	141.0	5	4.5
Bacterial Pneumonia	210.0	225.0	245.0	18	5.5	140.0	170.0	200.0	9	4.5	84.5	112.5	140.0	5	4.5
Influenza	210.0	225.0	260.0	18	5.0	140.0	175.0	200.0	9	4.5	87.5	120.0	148.5	5	4.0
Chronic Respiratory Disease	195.0	21[illegible].0	282.5	18	5.0	141.5	166.0	200.0	11	4.5	95.5	137.5	162.5	6	4.5
Mild Chronic Obstructive Disease	200.0	245.0	282.5	18	5.0	140.0	170.0	215.0	11	5.0	87.5	120.0	152.5	6	5.0
Severe Chronic Obstructive Disease	170.0	225.0	295.0	24	16.0	104.0	170.0	185.0	18	5.5	65.0	100.0	135.0	6	5.5

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Interquartile Range ≤ ½ of Median)

TABLE 18: Estimates of Effects on 0% of Population Category,
Photochemical Oxidant Concentrations (ppm)
Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	0.17	0.30	0.50			0.10	0.20	0.35			0.05	0.10	0.20		
Children	0.20	0.30	0.45			0.10	0.20	0.40			0.00	0.10	0.20		
Old Age	0.20	0.32*	0.42			0.10	0.20	0.30			0.03	0.10	0.20		
Heart Condition, Severe	0.20	0.30	0.40			0.10	0.23	0.35			0.05	0.15	0.25		
Heart Condition, Mild	0.20	0.35	0.50			0.10	0.23	0.35			0.03	0.15	0.25		
Hay Fever, Sinusitis	0.13	0.27	0.40			0.10	0.20	0.35			0.00	0.10	0.20		
Upper Respiratory Infection	0.13	0.30	0.45			0.10	0.20	0.35			0.00	0.10	0.20		
Asthma	0.13	0.30	0.50			0.10	0.20	0.30			0.03	0.10	0.20		
Viral Bronchitis	0.10	0.30	0.50			0.08	0.20	0.35			0.00	0.10	0.20		
Bacterial Pneumonia	0.15	0.30	0.50			0.10	0.20	0.40			0.00	0.10	0.20		
Influenza	0.15	0.30	0.42			0.10	0.20	0.35			0.05	0.10	0.20		
Chronic Respiratory Disease	0.20	0.30	0.55			0.10	0.20	0.40			0.00	0.10	0.20		
Mild Chronic Obstructive Disease	0.20	0.32	0.47			0.08	0.20	0.35			0.00	0.10	0.23		
Severe Chronic Obstructive Disease	0.10	0.20	0.35			0.05	0.13	0.23			0.00	0.10	0.20		

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated)

TABLE 19: Estimates of Effects on 10% of Population by Population Category,
Photochemical Oxidant Concentrations (ppm),
Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	0.55	0.75	1.10	19		0.40	0.50	0.80	12		0.13	0.30*	0.40	8	
Children	0.55	0.75	1.00	24		0.35	0.50	0.80	7		0.15	0.30*	0.42	7	
Old Age	0.40	0.70*	1.00	24		0.30	0.55*	0.85	24		0.20	0.30	0.50	6	
Heart Condition, Severe	0.40	0.60	0.80	24		0.30	0.52*	0.80	24		0.20	0.40*	0.55	24	
Heart Condition, Mild	0.47	0.80*	1.05	24		0.30	0.60*	0.88	20		0.20	0.40	0.50	6	
Hay Fever, Sinusitis	0.40	0.60*	0.93	22		0.25	0.50*	0.75	21		0.10	0.30*	0.40	12	
Upper Respiratory Infection	0.40	0.62*	0.92	36		0.30	0.50*	0.72	21		0.15	0.35	0.50	12	
Asthma	0.40	0.60*	0.95	24		0.20	0.40*	0.65	14		0.10	0.30*	0.50	8	
Viral Bronchitis	0.40	0.60	0.90	24		0.27	0.40	0.65	12		0.15	0.30*	0.50	12	
Bacterial Pneumonia	0.42	0.75	1.00	24		0.30	0.50*	0.70	17		0.10	0.30*	0.50	12	
Influenza	0.40	0.65*	1.00	24		0.30	0.40*	0.70	15		0.15	0.35	0.50	12	
Chronic Respiratory Disease	0.40	0.62	1.00	48		0.27	0.47	0.67	24		0.13	0.30*	0.42	14	
Mild Chronic Obstructive Disease	0.50	0.80*	1.02	48		0.30	0.50	0.80	24		0.20	0.40*	0.60	14	
Severe Chronic Obstructive Disease	0.30	0.50*	0.75	48		0.20	0.40*	0.60	30		0.10	0.20	0.38	18	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 20: Estimates of Effects on 50% of Population by Population Category,
Photochemical Oxidant Concentrations (ppm),
Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	0.75	1.10	1.40	24		0.50	0.80*	1.05	10		0.35	0.60	0.80	4	
Children	0.67	1.00*	1.25	24		0.50	0.70	1.15	12		0.35	0.60	0.75	6	
Old Age	0.80	1.00	1.30	24		0.47	0.75	1.00	24		0.30	0.50	0.65	12	
Heart Condition, Severe	0.60	0.95*	1.27	48		0.50	0.77*	1.05	24		0.27	0.50*	0.80	24	
Heart Condition, Mild	0.65	1.00*	1.40	24		0.42	0.80*	1.20	20		0.35	0.50	0.65	6	
Hay Fever, Sinusitis	0.60	0.85*	1.25	22		0.40	0.65*	0.95	21		0.20	0.40*	0.60	12	
Upper Respiratory Infection	0.62	0.92*	1.22	36		0.40	0.67*	0.95	22		0.27	0.50*	0.70	16	
Asthma	0.60	0.80	1.20	24		0.40	0.60*	0.95	17		0.23	0.40	0.60	11	
Viral Bronchitis	0.60	0.85	1.20	24		0.40	0.60	0.80	12		0.20	0.40*	0.60	12	
Bacterial Pneumonia	0.65	0.92	1.30	24		0.40	0.60*	0.90	17		0.20	0.40	0.67	12	
Influenza	0.60	0.82*	1.15	30		0.40	0.60*	0.80	10		0.20	0.40*	0.60	12	
Chronic Respiratory Disease	0.65	0.93*	1.20	48		0.45	0.70	1.00	24		0.30	0.50	0.60	8	
Mild Chronic Respiratory Disease	0.72	1.00*	1.38	48		0.50	0.80*	1.15	24		0.30	0.52*	0.80	14	
Severe Chronic Obstructive Disease	0.45	0.75*	0.98	48		0.35	0.55*	0.77	30		0.15	0.32	0.50	18	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 21: Estimates of Effects on 90% of Population by Population Category, Photochemical Oxidant Concentrations (ppm), Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	1.15	1.50	1.80	20		0.80	1.00	1.40	7		0.45	0.80	1.00	4	
Children	1.10	1.40	1.60	24		0.70	1.00	1.20	7		0.55	0.75	1.00	4	
Old Age	1.00	1.40	1.65	24		0.70	1.00	1.40	12		0.40	0.70	0.95	6	
Heart Condition, Severe	1.00	1.20	1.85	24		0.80	1.00	1.40	18		0.50	0.75	1.00	24	
Heart Condition, Mild	1.00	1.45	2.00	24		0.75	1.15	1.65	24		0.45	0.70	0.90	6	
Hay Fever, Sinusitis	0.80	1.00*	1.38	24		0.60	0.80*	1.05	21		0.30	0.50*	0.75	12	
Upper Respiratory Infection	0.80	1.20*	1.60	33		0.60	0.95*	1.20	21		0.50	0.70*	0.95	9	
Asthma	0.80	1.00*	1.40	24		0.60	0.80*	1.13	18		0.35	0.60*	0.80	11	
Viral Bronchitis	0.80	1.20*	1.60	36		0.55	0.80	1.05	12		0.30	0.60	0.85	12	
Bacterial Pneumonia	0.90	1.20	1.65	24		0.50	0.80	1.05	12		0.30	0.55	0.85	8	
Influenza	0.80	1.00	1.40	36		0.60	0.80*	1.02	20		0.35	0.60*	0.80	12	
Chronic Respiratory Disease	1.00	1.45*	1.80	24		0.70	1.05*	1.35	24		0.40	0.60	0.85	9	
Mild Chronic Obstructive Disease	0.88	1.20*	1.60	48		0.60	0.95	1.35	24		0.40	0.60	0.95	11	
Severe Chronic Obstructive Disease	0.60	1.00*	1.32	48		0.45	0.75*	0.95	30		0.23	0.42*	0.65	21	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 22: Estimates of Effects on 0% of Population by Population Category, Nitrogen Dioxide Concentrations (ppm), Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	1.50	2.50	3.50			1.00	1.60	2.60			0.50	1.00	1.90		
Children	1.55	2.50	3.45			1.00	1.60	2.65			0.50	1.05	1.80		
Old Age	1.50	2.25	3.30			1.00	1.50	2.50			0.50	1.20	2.35		
Heart Condition, Severe	1.35	1.90	2.85			0.60	1.55	2.40			0.20	0.75	1.45		
Heart Condition, Mild	1.50	2.35	3.50			1.00	1.60	2.85			0.45	1.00	1.85		
Hay Fever, Sinusitis	1.50	2.50	3.60			1.10	1.70	2.75			0.50	1.15	2.00		
Upper Respiratory Infection	1.50	2.25	3.40			1.00	1.50	2.55			0.50	1.00	2.00		
Asthma	1.35	2.00	3.50			1.00	1.60	2.70			0.65	1.10	1.75		
Viral Bronchitis	1.50	2.50	3.50			1.00	1.50*	2.60			0.70	1.25	2.00		
Bacterial Pneumonia	1.35	2.10	3.40			0.80	1.50*	2.55			0.50	1.00	1.85		
Influenza	1.35	2.45*	3.45			1.00	1.75	2.80			0.60	1.30	2.00		
Chronic Respiratory Disease	1.45	2.60	4.00			1.05	1.75	2.95			0.50	1.00	1.90		
Mild Chronic Obstructive Disease	1.55	2.35	3.50			1.00	1.60	2.90			0.45	1.00	1.70		
Severe Chronic Obstructive Disease	1.00	1.75*	3.00			0.65	1.30*	2.45			0.30	0.75	1.65		

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 23: Estimates of Effects on 10% of Population by Population Category,
Nitrogen Dioxide Concentrations (ppm),
Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	3.25	4.70	8.00	19		2.90	3.75	5.00	10		1.60	2.50	3.25	9	
Children	3.00	4.25	6.00	20		2.20	3.35	4.75	10		1.50	2.20	3.05	8	
Old Age	3.00	3.85	5.45	24		2.00	3.00	4.00	19		1.50	2.00	3.00	8	
Heart Condition, Severe	2.35	3.45	4.70	30		1.85	2.90	4.10	22		1.20	2.00	2.95	16	
Heart Condition, Mild	2.85	3.85	5.00	24		2.15	3.10	4.25	19		1.20	2.00	3.20	9	
Hay Fever, Sinusitis	2.95	3.50	4.85	19		2.00	3.00	4.25	12		1.50	2.40	3.50	9	
Upper Respiratory Infection	2.75	3.50	4.85	24		1.80	3.00*	4.20	16		1.45	2.10	3.20	9	
Asthma	2.60	4.00	5.00	24		1.85	3.15	4.10	11		1.25	2.45	3.50	8	
Viral Bronchitis	3.00	3.75	5.00	24		1.85	3.00*	4.00	16		1.15	2.10*	3.20	8	
Bacterial Pneumonia	3.00	4.25	5.25	24		1.50	2.75	4.00	16		1.00	1.85	2.85	11	
Influenza	2.60	3.50	4.90	27		2.00	3.00	4.25	17		1.25	2.10	3.25	11	
Chronic Respiratory Disease	2.90	3.75	5.00	36		2.50	3.30	4.20	24		1.15	2.00	3.10	11	
Mild Chronic Obstructive Disease	2.05	4.00	5.25	30		1.85	2.90	4.30	24		1.00	1.60	3.15	11	
Severe Chronic Obstructive Disease	1.85	3.00	4.25	33		1.40	2.35	3.65	24		0.85	1.50	2.50	12	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 24: Estimates of Effects on 50% of Population Category, Nitrogen Dioxide Concentrations (ppm), Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	4.30	8.00	11.50	20		3.25	4.50	7.60	11		2.15	3.25	4.60	9	
Children	4.00	6.50	10.00	22		3.05	4.25	6.20	11		2.15	3.00	4.25	9	
Old Age	4.00	6.00	8.00	24		2.80	4.00	5.90	19		2.20	3.00	4.05	10	
Heart Condition, Severe	4.00	6.00	8.00	31		3.00	4.00	5.00	22		2.00	3.00	4.00	16	
Heart Condition, Mild	3.75	5.50	8.00	24		3.25	4.15	6.00	20		2.35	3.10	4.60	9	
Hay Fever, Sinusitis	3.80	5.50	8.00	22		3.00	4.00	6.20	14		2.35	3.50	4.65	9	
Upper Respiratory Infection	3.25	4.50	7.60	24		2.70	3.75	4.90	16		2.30	3.10*	4.40	11	
Asthma	3.00	5.00	7.50	24		2.40	4.00	5.50	14		2.00	3.00	4.30	9	
Viral Bronchitis	4.00	5.50	8.00	24		3.00	4.00*	5.00	16		2.35	3.15*	4.25	10	
Bacterial Pneumonia	3.75	5.50	8.00	25		2.75	4.00	5.00	16		2.25	3.25	4.00	11	
Influenza	3.10	4.50	7.60	27		2.50	4.00	5.50	18		2.00	3.00*	4.50	12	
Chronic Respiratory Disease	3.50	4.90	8.00	36		3.00	4.20	6.00	24		2.25	3.20	4.25	11	
Mild Chronic Obstructive Disease	3.25	4.85	7.10	30		2.40	3.65	5.00	24		1.85	2.65	3.90	11	
Severe Chronic Obstructive Disease	2.50	3.60	5.00	33		1.85	3.05	4.40	24		1.30	2.10	3.65	12	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round. or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 25: Estimates of Effects on 90% of Population by Population Category, Nitrogen Dioxide Concentrations (ppm), Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	6.00	10.00	13.50	19		4.00	6.00	10.00	10		3.50	4.90	6.00	8	
Children	5.50	8.00	11.50	24		3.70	5.50	9.50	11		3.20	4.65	5.65	10	
Old Age	4.50	8.00	10.00	24		3.05	5.00	8.00	22		3.00	4.00	4.85	11	
Heart Condition, Severe	5.00	8.00	10.00	31		3.40	5.50	7.50	22		2.40	3.50	4.50	17	
Heart Condition, Mild	5.00	8.00	10.50	24		4.00	6.00	8.50	22		3.00	4.00	5.00	10	
Hay Fever, Sinusitis	4.50	7.00	10.00	22		3.75	5.50	8.00	14		2.85	4.00	5.15	9	
Upper Respiratory Infection	4.25	5.75	9.50	24		3.50	4.75	8.00	16		2.70	4.00	5.40	11	
Asthma	4.00	6.00	8.50	24		3.50	5.00	8.00	14		3.00	4.00	5.00	9	
Viral Bronchitis	4.75	7.00	10.00	24		4.00	5.00	8.00	16		3.00	4.00	5.50	11	
Bacterial Pneumonia	4.35	6.50	9.00	32		3.50	5.00	7.50	16		3.00	4.00	4.85	12	
Influenza	4.00	6.00	9.50	33		3.25	5.00	8.00	20		2.50	3.85	5.00	13	
Chronic Respiratory Disease	4.50	6.00	9.50	36		4.00	5.00	7.00	24		2.65	3.70	4.80	12	
Mild Chronic Obstructive Disease	4.00	6.00	9.00	30		3.00	4.80	6.10	24		2.60	3.55	4.60	12	
Severe Chronic Obstructive Disease	3.25	4.50	6.40	33		2.50	3.60	5.05	24		2.00	3.00*	4.00	12	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 26: Estimates of Effects on 0% of Population by Population Category,
Carbon Monoxide Concentrations (ppm),
Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	80.0	110.0	150.0			40.0	80.0	109.0			21.0	45.0	72.5		
Children	72.5	100.0	150.0			40.0	60.0	100.0			20.0	35.0	55.0		
Old Age	65.0	100.0	142.5			40.0	62.5	96.5			17.5	32.5	60.0		
Heart Condition, Severe	40.0	60.0*	90.0			30.0	45.0	72.5			12.5	25.0	47.5		
Heart Condition, Mild	50.0	77.5	112.5			32.5	50.0	85.0			10.0	30.0	50.0		
Hay Fever, Sinusitis	67.5	97.5	135.0			30.0	60.0	100.0			20.0	40.0	60.0		
Upper Respiratory Infection	65.5	100.0	142.5			40.0	60.0	90.0			20.0	40.0	62.5		
Asthma	67.5	100.0	140.0			40.0	60.0	97.5			20.0	37.5	60.0		
Viral Bronchitis	67.5	100.0	145.0			40.0	65.0	100.0			20.0	40.0	60.0		
Bacterial Pneumonia	62.5	100.0	142.5			35.0	60.0	90.0			15.0	40.0	52.5		
Influenza	62.5	97.5	141.0			35.0	60.0	85.0			20.0	35.0	60.0		
Chronic Respiratory Disease	65.0	100.0	140.0			32.5	59.0	85.0			19.5	39.5	59.5		
Mild Chronic Obstructive Disease	65.0	100.0	142.5			32.5	60.0	85.0			20.0	40.0	60.0		
Severe Chronic Obstructive Disease	60.0	92.5*	120.0			30.0	60.0	82.5			17.5	32.5	52.5		

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 27: Estimates of Effects on 10% of Population by Population Category, Carbon Monoxide Concentrations (ppm), Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	177.5	205.0	250.0	20		125.0	160.0	196.5	12		60.0	100.0	127.5	7	
Children	146.0	187.5	237.5	21		105.0	145.0	197.5	12		50.0	80.0*	101.5	8	
Old Age	150.0	180.0	210.0	22		105.0	140.0	175.0	14		50.0	80.0*	105.0	10	
Heart Condition, Severe	55.0	100.0	140.0	22		57.5	80.0	115.0	17		30.0	55.0	80.0	12	
Heart Condition, Mild	120.0	155.0	195.0	12		80.0	120.0	157.5	17		50.0	72.5*	102.5	11	
Hay Fever, Sinusitis	137.5	170.0	225.0	22		110.0	130.0	160.0	12		60.0	80.0*	108.5	10	
Upper Respiratory Infection	130.0	167.5	200.0	24		90.0	135.0	180.0	12		50.0	80.0*	108.0	11	
Asthma	132.5	172.5	232.5	24		105.0	140.0	174.0	13		53.5	84.0*	114.0	12	
Viral Bronchitis	115.0	162.5	192.5	24		75.0	120.0	170.0	15		51.0	80.0*	113.0	10	
Bacterial Pneumonia	125.0	170.0	200.0	24		77.5	115.0	159.5	14		42.5	77.5*	100.0	10	
Influenza	115.0	151.0	198.0	24		80.0	120.0	155.0	12		45.0	70.0	102.5	11	
Chronic Respiratory Disease	100.0	150.0	199.0	24		80.0	120.0	160.0	13		44.0	75.0*	97.5	11	
Mild Chronic Obstructive Disease	117.5	152.5	200.0	24		95.0	127.5	157.5	13		40.0	65.0	100.0	11	
Severe Chronic Obstructive Disease	100.0	140.0	175.0	24		72.5	100.0	145.0	19		32.5	60.0	92.5	12	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

TABLE 28: Estimates of Effects on 50% of Population by Population Category,
Carbon Monoxide Concentrations (ppm)
Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	200.0	262.5	300.0	20		150.0	182.5	230.0	12		85.0	120.0*	155.0	7	
Children	190.0	235.0	300.0	20		125.0	165.0	200.0	10		80.0	105.0*	137.5	8	
Old Age	170.0	210.0	300.0	22		125.0	167.5	200.0	12		71.0	103.5*	139.0	10	
Heart Condition, Severe	104.0	161.0	205.0	24		90.0	122.5	166.0	17		40.0	65.0	100.0	11	
Heart Condition, Mild	155.0	180.0	205.0	12		120.0	150.0	185.0	17		80.0	110.0*	140.0	11	
Hay Fever, Sinusitis	195.0	250.0	300.0	22		125.0	180.0	200.0	12		80.0	115.0*	140.0	11	
Upper Respiratory Infection	185.0	225.0	300.0	24		122.5	175.0	200.0	12		75.0	105.0	137.5	12	
Asthma	195.0	225.0	287.5	24		125.0	172.5	200.0	12		80.0	110.0*	136.5	11	
Viral Bronchitis	180.0	215.0	300.0	24		122.5	160.0	200.0	15		80.0	100.0	140.0	11	
Bacterial Pneumonia	165.0	200.0	240.0	24		110.0	150.0	200.0	15		65.0	100.0*	123.0	10	
Influenza	180.0	215.0	300.0	24		127.5	167.5	200.0	15		80.0	105.0	131.0	12	
Chronic Respiratory Disease	160.0	200.0	250.0	24		112.5	155.0	197.5	13		60.0	95.0*	120.0	12	
Mild Chronic Obstructive Disease	165.0	205.0	255.0	24		122.5	155.0	197.5	15		70.0	100.0	125.0	12	
Severe Chronic Obstructive Disease	140.0	180.0	200.0	24		100.0	140.0*	180.0	19		60.0	90.0	115.0	12	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation $\leq$ 1/3 of Median for estimates iterated on second round, or Interquartile Range $\leq$ ½ of Median for estimates not iterated).

TABLE 29: Estimates of Effects on 90% of Population by Population Category, Carbon Monoxide Concentrations (ppm), Second Round Survey

POPULATION CATEGORY	INCAPACITY					DISABILITY					DISCOMFORT				
	Yl	X	Yu	T	R	Yl	X	Yu	T	R	Yl	X	Yu	T	R
Normal	250.0	300.0	400.0	20		177.5	225.0	290.0	12		114.0	135.0	155.0	7	
Children	205.0	300.0	375.0	20		165.0	200.0	245.0	12		98.0	125.0	152.5	6	
Old Age	200.0	300.0	375.0	22		165.0	200.0	250.0	14		91.0	130.0*	165.0	10	
Heart Condition, Severe	145.0	190.0	245.0	24		109.0	150.0	200.0	21		65.0	90.0	120.0	11	
Heart Condition, Mild	175.0	215.0	255.0	22		142.5	170.0	200.0	16		92.5	119.0*	160.0	11	
Hay Fever, Sinusitis	235.0	300.0	375.0	22		172.5	200.0	257.5	12		114.0	135.0	158.5	6	
Upper Respiratory Infection	200.0	300.0	355.0	24		160.0	200.0	252.5	14		109.0	140.0	182.5	6	
Asthma	200.0	300.0	350.0	24		152.5	197.5	242.5	15		97.5	130.0	157.5	6	
Viral Bronchitis	200.0	300.0	350.0	24		150.0	200.0	250.0	13		97.5	131.0	157.0	11	
Bacterial Pneumonia	192.5	215.0	275.0	24		150.0	180.0	205.0	15		90.0	120.0*	140.0	10	
Influenza	205.0	300.0	355.0	24		155.0	200.0	250.0	15		100.0	135.0*	160.0	12	
Chronic Respiratory Disease	200.0	225.0	300.0	24		152.5	180.0	200.0	15		97.5	125.0*	159.5	12	
Mild Chronic Obstructive Disease	200.0	275.0	325.0	24		155.0	190.0	225.0	15		102.5	140.0*	160.0	12	
Severe Chronic Obstructive Disease	167.5	205.0	262.5	24		121.0	170.0	200.0	20		70.0	100.0	140.0	12	

Yl = Lower Limit Estimate (ppm)
X = Best Estimate (ppm)
Yu = Upper Limit Estimate (ppm)
T = Time Duration of the Effects (hour)
R = Self-Ratings of Panel Member
* = Value with Good Group Agreement (Standard Diviation ≤ 1/3 of Median for estimates iterated on second round, or Interquartile Range ≤ ½ of Median for estimates not iterated).

SECTION 7

DISCUSSION

A. GENERAL COMMENTS

Due to the voluminous quantity of data generated from this study, discussions in this report will be mostly restricted to the finalized results which include data obtained in the second round and those from the first round that do not require reiteration.

Based on the criterion given under the method section, the second round estimates are classified as "good agreement" or not. Judging by the numbers of "good agreement" answers, it might seem that the Delphi approach does not work out very well in this study. However, if one examines closely the distribution of answers for each pollutant, population group and condition, and compares these answers with available experimental data, one will conclude that Delphi procedures are appropriate for arriving at group estimates. As it is discussed below under Section C, the Delphi data are generally comparable with available experimental data. The limited number of "good agreement" answers in the finalized results, especially in the area pertaining to the health effects of nitrogen dioxide and carbon monoxide, is really a reflection of the lack of actual data to form a basis for the panelists to come to a better group agreement, rather than a deficiency of the Delphi techniques. This comment, however, should be taken with a certain amount of caution. Although the panel members participating in the study are considered experts in the field of air pollution health effects, their degree of knowledge and philosophy vary. These differences may explain some of the variability of answers in areas where there is a lack of experimental data.

In spite of the fact that the dispersion is wide on a large portion of the estimates, these estimates turn out to have a reasonable form of consistency. The panelists were asked to estimate both the concentrations at which 10% and 90% of a given population would experience a given impairment, and the concentrations at which they were 5% and 90% certain that a given fraction of the population would experience the impairment. The two estimates are not logically dependent; however, because of the lack of information in this task situation, it seems unlikely that a sharp discrimination could be made between the two types of estimates. This would suggest that a fair amount of redundancy exists in the data if the panelists are being consistent. One simple hypothesis to test the existence of redundancy is that the 10% and 90% estimates on population are similar to the 5% and 95% estimates of certainty for the 50% estimate on population.

The hypothesis was tested on a subset of the data, namely, the 27 cases Normal, Children, and Severe Heart Condition, for the three levels of impairment and the three pollutants. In each of the 27 cases, the 5% and 95% confidence limits for the 50% population estimate, and the 10% and 90% population estimates were divided by the 50% population estimate to make the various cases comparable--in effect, normalizing the Y_L, Y_U, X_{10} and X_{90} estimates to the X_{50} estimates.

Table 30 displays the mean normalized Y_L and Y_U estimates and the mean normalized X_{10} and X_{90} estimates for the 27 cases. The similarity between mean Y_L and X_{10} and Y_U and X_{90} is striking. Inspection of individual estimate indicates that in many of the 27 cases, the Y_L and X_{10} or Y_U and X_{90} are in fact, identical. In summary, the answers put forth by the panelists, especially in area where no experimental data exist, are not just random estimates.

TABLE 30: Comparison of Mean for Lower and Upper Limits (Y_L and Y_U) for 50% Population with the Mean Best Estimates for 10% and 90% Population (X_{10} and X_{90}, All Normalized to X_{50})

Y_L	.67	.70	X_{10}
Y_U	1.29	1.25	X_{90}

B. DOSE-RESPONSE MODELS

A glance at the data suggests that the dose-response relationship expressed in the median estimates is S-shaped. A number of models are available to represent this type of relationship. The model used in the present study is the threshold or susceptibility level model. This approach assumes that each individual is characterized by a susceptibility level (reaction threshold) which has some distribution in the population. A first thought might be that the distribution is normal. However, there is a fixed lower bound to the dosage, namely zero; a frequently encountered distribution for quantities with fixed lower bound is the log-normal. In the log-normal case, the population is distributed normally on the logarithm of the quantity.

Assuming log normality for the distribution of susceptibility, the density of individuals whose threshold is concentration (c) x one hour (for a given pollutant, a given degree of impairment, and a given population type) would be expressed by:

$$\frac{B\,\phi(z)}{c} \quad \text{where } z = A + B\,(\ln c)$$

$\phi(z)$ is the normal density function with mean 0 and standard deviation = 1, and A, B are constants computed by least squares. Since the panel was asked to estimate the dosage for given fractions of the population, a more convenient form for computation is the cumulative distribution, where F is the fraction of the population affected,

$$F = \int_{-\infty}^{z} \phi\,(x)dx$$

This model is often referred to as the PROBIT model.

Although the PROBIT model is intuitively clear, it has the drawback that computation is cumbersome, especially if curve fitting is to be carried out for a large number of cases, since there is no elementary closed form for the inverse of the cumulative distribution function.

Another model is the logistic (LOGIT) model. The LOGIT model can be thought of as an extension of the familiar accretion rate type of relationship where the fractional increase in the number of individuals affected is is proportional to the number remaining (unaffected) and the fractional increase in dosage. In differential notation

$$\frac{dF}{F} = B'(1-F)\,\frac{dc}{c}$$

When this expression is integrated we obtain

$$\ln\frac{F}{1-F} = A' + B'\ln c$$

Since F and c are obtainable directly from the estimates, it is straightforward to compute the constants A' and B' by least squares. In fitting the dose-response curves, three points are computed. Each point is derived with the following expression: A' + B'ln c

$$F = \frac{e^{A' + B'\ln c}}{1 + e^{A' + B'\ln c}}$$

when F is the affected population fraction.

Although the LOGIT and PROBIT models are based on quite different assumptions, they generate very similar dose-response relationships. This is difficult to demonstrate analytically.* However, the similarity can be shown graphically.

Figure 5 shows the density distributions for the LOGIT and PROBIT analysis, where the curves are fitted to the points F = .95, c = 1 and F = .5, c = .5.

Figure 6 shows the cumulative (dose-responsive) curves generated by the density functions of Figure 5. In both figures the solid line is the LOGIT analysis. The dashed line in Figure 5 is the PROBIT case. The

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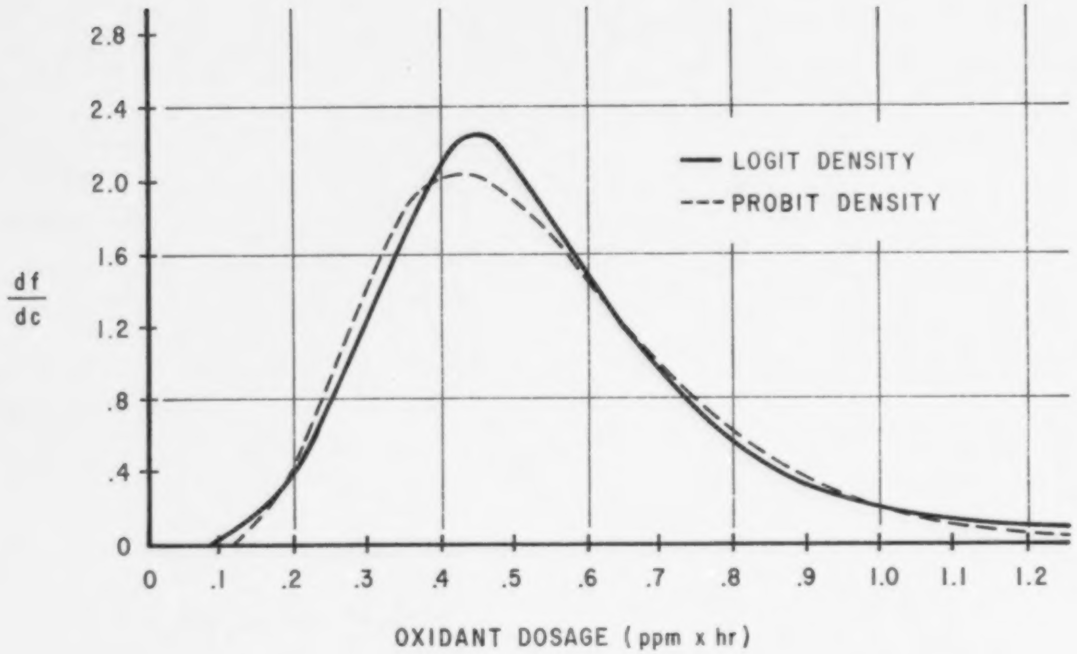
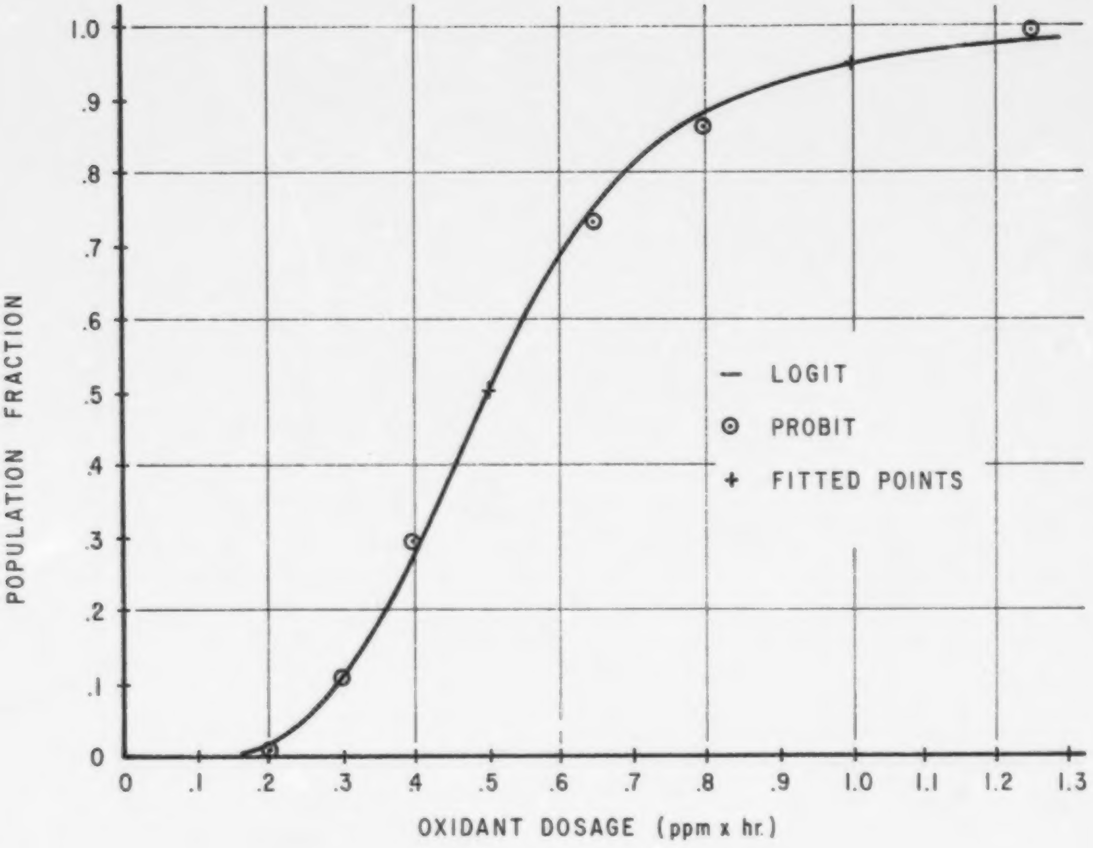
* Birmbaum reports that Haley has demonstrated that $1\{\phi(x) - \chi(1.7\chi\} 1 < 0.01$ for all χ, where ϕ is the normal density function and χ is the logistic function in "Statistical Theories of Mental Test Scores" by F. M. Lord, M. R. Norick. Addison-Wesley Publ. Co., 1968. Pages 399-407.



COMPARISON OF LOGIT AND PROBIT DENSITY FUNCTIONS

FIGURE -5-



COMPARISON OF LOGIT AND PROBIT
DOSE-RESPONSE CURVES

FIGURE -6-

PROBIT case in Figure 6 is shown by the circled dots. The PROBIT curve is not drawn in because it is almost indistinguishable from the LOGIT curve.

As can be seen from the figures, the LOGIT density distribution differs somewhat from the PROBIT distribution, especially in the vicinity of the peaks, where the LOGIT distribution has a higher peak. However, the differences tend to wash out when the cumulative distributions are calculated.

For those who prefer the susceptibility model as a basis for the dose-response relationship, the LOGIT analysis can be interpreted as a convenient approximation, where the log-normal density distribution of thresholds is replaced by the "near log-normal" density distribution of the LOGIT function. Of course, some researchers may find the assumptions of the LOGIT analysis more persuasive.

One question remains. Although the two models are highly similar when fitted exactly to two points, serious discrepancies might arise when the two models are approximated by least squares to more than two points. To check this possibility, Figure 7 shows the least squares fit of the LOGIT and PROBIT models to the case Oxidant, Normal, Discomfort, X, where the LOGIT model gives a very good fit to the panel estimated points (crosses in Figure 7). Figure 8 shows the least squares fit to the case Oxidant, Normal, Disability, X, where the LOGIT model does not give a particularly good fit. As the figures indicate, the least squares computation generates about the same dose-response curve for the two models in each case.

In the present analysis, only three data points are being fitted for each dose-response curve, namely the median estimates of dose for 10%, 50%, and 90% of population affected. It might appear that the data imposes very little restriction on the model to be employed, and that, in fact, any S-shaped curve with two undetermined constants would fit the data equally well. This is not quite the case. The underlying phenomena dictate that the dose-response curve fall to zero at least in the vicinity of zero, and that it approach 1 asymptomatically with increasing dose. If a relationship of the type

$$F = e^{(a + \frac{b}{c})}$$

is postulated, as $c \to \infty$, $b/c \to 0$, and a must be 0 in order for $F \to 1$. Hence, there is in reality only one constant to be determined by the data. This formula gives a poor fit to the data, as the dashed curve in Figure 7 illustrates.

Another widely used S-curve is the so-called Gomperz curve

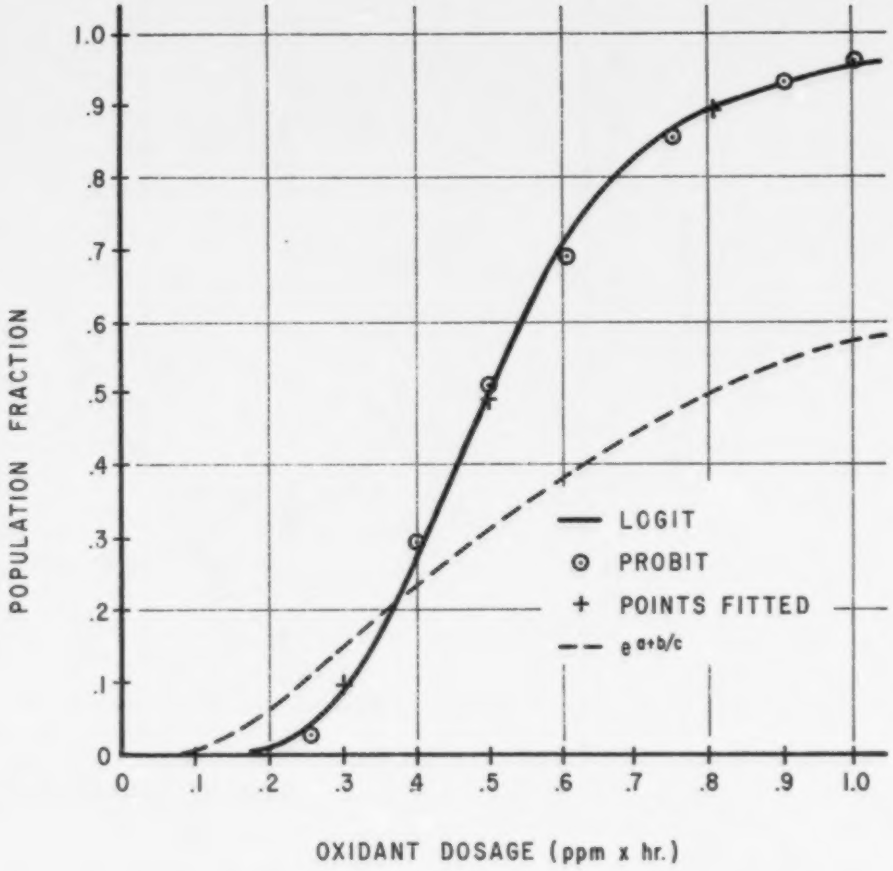
$$F = k\, a^{b^c}$$

or in logarithmic form

$$\ln F = \ln k + (\ln a) b^c$$

The process constraints ($F = 0$ when $c = 0$, $F = 1$ when $c = \infty$) imply that $k = 1$, $a < 1$ and $b < 1$. Strictly speaking, the Gomperz curve cannot fulfill the constraints, since $F = a$ at $c = 0$; however, if a is a very small number this may not be serious.

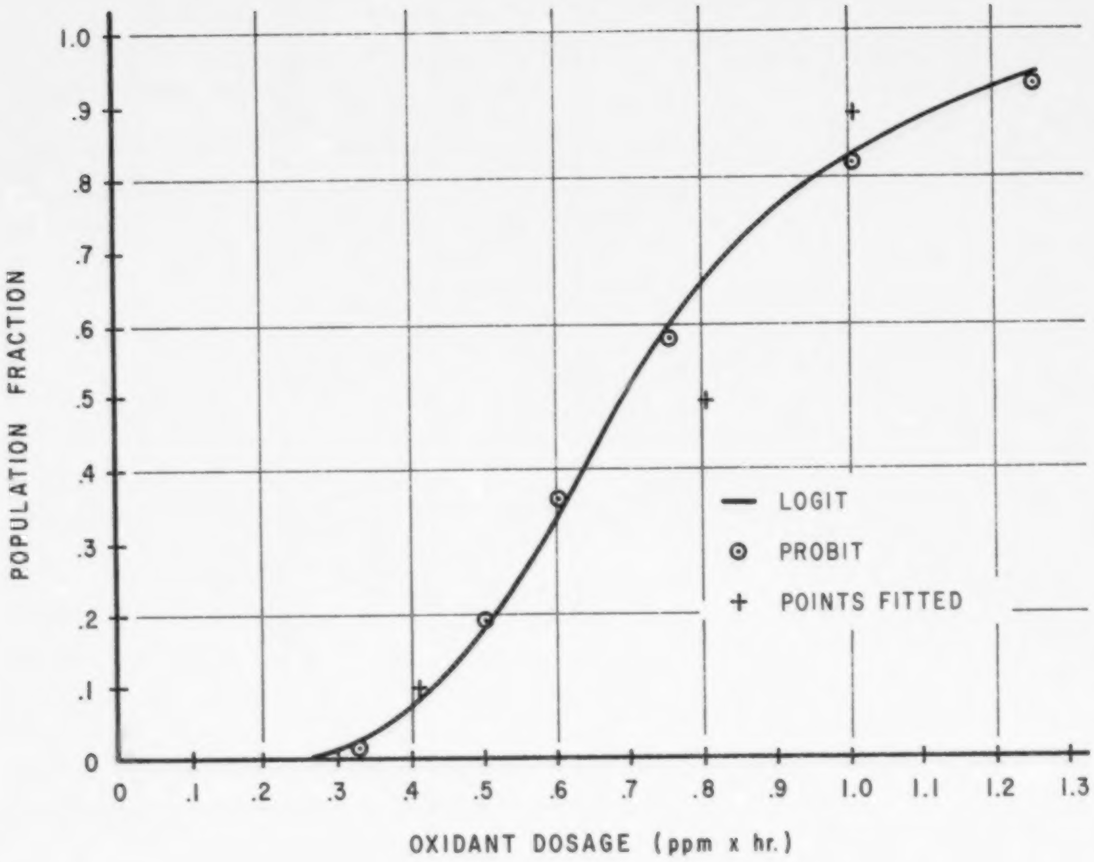
In fact, the Gomperz curve does appear to fit the data fairly well, at least for the cases Normal, Disability, X for each of the three pollutants. For CO, the least squares $a = 1/e^{4040}$, a very small number indeed! Hence, the fact that the LOGIT anlaysis gives a good fit to most of the data cannot be interpreted as a confirmation of the susceptability model. The principal advantages of the LOGIT analysis are that the underlying model is relatively clear and curve-fitting is computationally convenient.



COMPARISON OF LOGIT AND PROBIT

LEAST SQUARES FIT ON THE ESTIMATES (x) OF OXIDANT DOSAGE CAUSED DISCOMFORT ON NORMAL POPULATION.

FIGURE - 7-



COMPARISON OF LOGIT AND PROBIT

LEAST SQUARES FIT ON THE ESTIMATES (x) OF OXIDANT DOSAGE CAUSED DISABILITY ON NORMAL POPULATION

FIGURE -8-

C. DELPHI DATA vs. EXPERIMENTAL DATA

Oxidant

The conditions that were queried in regard to the effects of photochemical oxidant were discomfort as manifested by eye irritation, non-productive coughing or chest tightness, disability as manifested by headache, and incapacity due to respiratory or cardiac abnormalities or bronchopneumonia. Eye irritation,[1,19] non-productive cough and chest tightness or soreness[20-23] are the earliest manifestations of exposure to photochemical oxidant. Headache due to the irritative properties of ozone[1,23] is likely to be a more significant manifestation as this symptom often diminishes ability to concentrate. Respiratory and cardiac problems as well as bronchopneumonia are potentially incapacitating complications of oxidant exposure. Experimental data on oxidant effects relevant to this study are summarized in Table 31.

Analysis of the estimates for each category of response in normal children, adults, and the elderly indicates consistency in the answers of the panel. This agreement of opinion was most apparent in the estimates for the 10 or 50% dose-response rate. Less agreement was found in the experts' estimates as to the upper and lower levels of human sensitivity to oxidants. According to the experts, a one hour exposure to 1.50 ppm of oxidant would cause incapacity in 90% of normal adults, 1.02 ppm would cause incapacity in 50%, .77 ppm would incapacitate 10%, and 0.30 ppm or less would not incapacitate anyone (Table 6-9). Slightly lower levels would incapacitate the more sensitive group such as the children or the elderly. Disability due to headache was predicted to occur in 90% of normal adults after a one hour exposure to 1.00 ppm of oxidant, in 50% after exposure to 0.80 ppm, in 10% after exposure to 0.41 and in none who were exposed to 0.20 ppm or less; the predictions for discomfort were 0.80 ppm, 0.50 ppm, 0.30 ppm and 0.10 ppm. Again slightly lower values were predicted for the dose-response relationships of disability and discomfort in children and the elderly.

TABLE 31 : Summary of Experimental Data on Oxidant Effects Relevant to the Delphi Data

Concentration (ppm)	Exposure Time	Subjects	Effects	Reference
0.37-0.70	2 hrs.	Human	Cough, nasopharyngeal irritation, substernal soreness, chest tightness; symptoms accentuated with excercise	20, 21, 22
>.30	--	Human	Eye irritation due to some photochemical products	19
1	--	Human	Dyspnea, headache in most subjects	23
0.37-0.7	2 hrs.	Human	Dyspnea, headache in 50% of subjects	20, 21
1.0-2.0	--	Human	Incapacitating illness	30, 31
0.38-1.59	--	Mice	Presence of silicosis did not affect murine ability to resist bacterial challenge; this is contrary to accepted clinical assumption	42
0.8-1.7	--	Human	Pulmonary congestion	26
0.5	--	Human	Edema formation	47, 48
0.25	--	Human	Less than 6% of asthmatic may have attacks precipitated when oxidant concentration >.25 ppm	50

The consistency of the expert opinion probably reflects the extensive literature which is available in regard to these dose-response relationships. Numerous investigators have studied the affect of similar exposures in volunteers,[2,20,25] accidental poisonings[26-31] and in experimental animal models.[32-35] Exposure to 0.37 ppm of ozone produces the same symptoms in some volunteers.[20] Eye irritation, a very sensitive indicator of photochemical smog, is often due to photochemical products rather than ozone.[19] This abnormality can be present when oxidant concentrations are less than 0.3 ppm. The similarity of these experimental results with the estimates provided by the panel of experts is obvious.

Although headache occurs secondary to oxidant exposure, dyspnea is more frequent and as such this symptom would have been a slightly better index of disability. Most volunteers develop dyspnea and headache when exposed to 1.0 ppm of ozone.[23] These symptoms occur in less than 50% of volunteers who are exposed to 0.7 or 0.37 ppm of ozone.[20,21,22] Data concerning the threshold value for these symptoms has not been reported. The experimental results closely approximate the estimates of the experts.

Data concerning the dose-response relationship for illness such as respiratory infection are derived from accidental exposure and as such are fragmentary as well as imprecise. The few reports that are available suggest that short term exposure to 1.0 to 2.0 ppm of oxidant will cause incapacitating illness.[30,31] Whether lesser exposures can also induce illness is unknown. The opinion of the experts was that a one hour exposure to 1.50 ppm of oxidant would result in incapacity in 90% of normal adults, an estimate that is consistent with these data. The estimates for illness in 50% of normal adults (1.02 ppm) and in 10% of normal adults (0.77 ppm) are also in accord with experimental data, as these levels of exposure will undoubtedly produce dyspnea, cough and ventilatory disturbances.[20,21,22] The panel did not agree very well on the estimate that exposure to 0.30 ppm would not be incapacitating. This value would appear to be valid however since numerous volunteers have been subjected to higher concentrations of oxidant without incurring illness. Results from tests in sensitive animal models also fail to show abnormalities at these exposure levels.[32,33]

Volunteer or accidental toxicity data for these dose-response relationships for children and the elderly are not available. Experiments with young animals have shown an increased susceptibility to the acute toxic effects of ozone.[1] Although experiments with "old" animals have not been reported, it seems likely that the age-related decrease in cardio-pulmonary function would enhance susceptibility to oxidant induced injury. Therefore, even though the estimates for the dose-response relationship for these groups cannot be evaluated objectively, they seem reasonable.

There was general agreement by the experts that patients who were compromised by either a viral or bacterial illness would have enhanced susceptibility to oxidant induced abnormalities. Good agreement was observed on the estimates by the experts of the dose-response relationship for discomfort, disability, and incapacity in 10%, 50% and 90% of individuals with acute viral bronchitis and influenza. According to the experts, cough (discomfort), dyspnea (disability), bacterial pneumonia or acute respiratory failure (incapacity) would result in children and elderly from exposure to levels of photochemical oxidant that were less than the levels necessary to produce discomfort, disability, or incapacitation in healthy adults. The two infections of the lower respiratory tract were affected to a similar degree with 90% of infected individuals experiencing increased dyspnea at 0.80 ppm of oxidant and increased cough at 0.60 ppm. Ten percent of the infected population would be incapacitated from either superimposed bacterial pneumonia (influenza) or acute respiratory failure (viral bronchitis) by exposure to 0.65 or 0.60 ppm of oxidant. Exposure to 0.30 ppm of oxidant would cause discomfort as manifested by cough or with influenza cough and pleuritic pain. The estimates by the experts also showed statistical agreement regarding increased sensitivity to oxidant exposure for the 10%, 50%, and 90% population categories in individuals with upper respiratory infections. The concentrations of oxidant necessary to produce adverse effects of discomfort, disability and incapacity were slightly higher than those necessary to produce the same effect in patients with influenza or viral bronchitis. Although the estimates of the levels of oxidant which would cause increases in discomfort, disability and incapacity for the various population categories with bacterial pneumonia were usually not statistically significant, the trend parallelled the estimated values for influenza. None of the estimates for these disease states showed good group agreement in the 0% population category. Hence, it would appear that the experts agreed that exposure to 0.30 ppm or higher of oxidant would be harmful to some individuals with acute infection but they could not agree on the lower limit of oxidant sensitivity. The conclusion that oxidant exposure would enhance symptoms or worsen already present dysfunction is consistent with a large body of evidence indicating an additive interaction of oxidant exposure and infection.[2,3,32-35] The estimates for concentrations of oxidant which would cause discomfort, disability and incapacity are quantitatively similar to ones which cause cough and dyspnea in normal individuals,[20,21] depress resistance to bacterial infection in murine models[32,37,38] and result in murine pneumonia.[33,39,40] The conclusion that already infected individuals will have enhanced susceptibility to ozone induced abnormalities is also supported by data obtained in volunteers in which stress such as exercise significantly increased sensitivity to oxidant damage.[41]

According to the experts, patients with chronic lung disease would manifest increased sensitivity to photochemical oxidants if their underlying illness involved infection. Althought the dose-response estimates did not always have good group agreement, the overall trend for the expert opinion indicates that patients with chronic respiratory illnesses of a non-infectious nature such as a pneumoconiosis or sarcoidosis are not inordinately sensitive to photochemical oxidants. The only experimental data which bear on this point consist of murine experiments in which mice with silicosis were exposed to atmospheres of photochemical oxidant (0.38 - 1.59 ppm) during a bacterial challenge.[42] The presence of silicosis did not affect murine ability to resist the bacterial challenge.[42]

It should be noted that this apparent lack of interaction between the presence of a pneumoconiosis and susceptibility to infection is contrary to the accepted clinical assumption that such an interrelationship does exist.[43,44]

The experts uniformly considered photochemical oxidant exposure as a precipitating cause of dyspnea (discomfort), exacerbation of bronchitis (disability) and bronchopneumonia (incapacity) in patients with chronic obstructive lung disease. Except for the 0% population category, good agreement among the experts was shown in almost all of the dose-response estimates. Respiratory abnormalities would be exacerbated in 90% or more of patients with mild chronic respiratory disease by exposure for one hour to higher concentrations of photochemical oxidant 0.6 ppm or more. At these levels of exposure patients with mild chronic respiratory disease tolerated photochemical oxidant less well than comparably aged healthy adults. The experts were also in agreement that this difference in sensitivity would not exist at the lower levels of exposure. Comparison of the predictions for discomfort, disability, and incapacitation of 10% of the population shows that patients with mild chronic respiratory disease can withstand the same or slightly higher levels of exposure as well as healthy adults. Discomfort, disability and incapacity were markedly increased in patients with severe chronic respiratory disease by exposure to photochemical oxidant. The dose-response estimates uniformly indicated a 25 to 40% increase in sensitivity to photochemical oxidants for all segments of this population category. The threshold level at which a minimal effect defined in this case as dyspnea, might be expected was in the range of 0.20 to 0.30 ppm. The few studies which have been performed in individuals with severe chronic respiratory disease are in agreement with the conclusion that this population group is most susceptible to the deleterious effects of photochemical oxidant.[43,44] Experimental evidence which has been previously cited[1,32,33,37-40,45] further supports the experts' contention that the presence of severe underlying lung disease, hypoxia, and infection provides a uniquely susceptible substrate for oxidant induced damage.

The experts' estimates of the dose-response relationship for discomfort, disability and incapacity of 10,50, and 90% of individuals with mild or severe heart conditions tended to agree in most instances. According to the experts 20% or more of patients with mild heart disease were likely to develop discomfort due to dyspnea after exposure to 0.40 ppm or more of oxidant. More serious disability (congestive heart failure) was predicted after exposure to 0.60 ppm or greater. Pulmonary edema could be anticipated in some patients who were exposed to 0.8 ppm or greater and the lower threshold for effect (0% population) was estimated to be 0.35 ppm. The predicted oxidant concentrations which would cause discomfort (dyspnea) were slightly higher than concentrations that were estimated to cause the same effect in the elderly. The fact that slightly higher concentrations of oxidant were estimated to be necessary to cause disability or incapacitation in patients with mild heart disease than in the elderly can be attributed to differences in the medical conditions which were queried in regard to these conditions. Much more severe conditions, heart failure or pulmonary edema, were chosen for these responses because they represent the major consequences of oxidant exposure in patients with heart disease. The experts predicted discomfort (worsening of congestive heart failure), disability (pulmonary edema), and incapacitation (angina or myocardial infarction) in 10% of this population group for exposure levels which exceeded 0.40 ppm, 0.52, and 0.60.

The experts' opinions were probably based at least in part on the edemagenic properties of ozone. Edema formation with resultant pulmonary congestion, bronchoconstriction, hypoxia and secondary infection is the major cause of toxicity in humans.[1,27,28] In normals pulmonary congestion due to ozone induced edema occurs after exposure to 0.8 to 1.7 ppm.[26] Numerous experimental studies have demonstrated edema formation after exposure to as little as 0.5 ppm of ozone.[47,48] The estimate that some individuals already compromised by heart failure might develop pulmonary edema after exposure to 0.52 ppm of ozone agrees with these data. Neither epidemiological nor experimental data bearing on the relationship of oxidant exposure to angina pectoris or myocardial infarctions has been reported. However, the increased sensitivity to ozone during exercise suggests that under normal circumstances individuals with severe coronary disease may be stressed sufficiently by exposure to oxidant to infarct compromised tissues.

Excellent agreement among the experts existed in the dose-response estimates for 10, 50, and 90% of individuals with allergic conditions (asthma, hay fever or sinusitis). According to the experts concentrations of 0.6 to 1.0 ppm of oxidant would incapacitate asthmatic patients (status asthmaticus) or patients with hay fever, or sinusitis (nasal or sinus drainage and headache), concentrations of 0.4 to 0.8 ppm would cause disability (asthmatic attack, nasal or sinus drainage) and concentrations of 0.3 to 0.6 ppm would cause discomfort (dyspnea, nasal or sinus discomfort). As was the case with most of the disease categories, the threshold estimates below which no effect would occur were unreliable.

This finding of good agreement among the experts for most of the dose-response estimates as regards asthma is not surprising since data exist from human and non-human investigations proving that bronchoconstriction is a very sensitive index of oxidant exposure.[1,2,20,32,39] The uniform occurrence of ozone induced bronchoconstriction is the basis for the general belief that oxidant exposure precipitates respiratory abnormalities in asthmatic individuals. Data proving this association, however, are meager. This is in part due to the understandable reluctance of investigators to expose patients with asthma to oxidant atmospheres. The one published epidemiological study indicates that a rather small proportion (less than 6%) of asthmatics may have attacks precipitated when oxidant concentrations exceed 0.25 ppm.[50] Data from experiments with guinea pigs confirm the likelihood of this relationship, as animals that were exposed to ozone prior to inhaling acetylcholine manifested immediate respiratory embarrassment similar to anaphylaxis.[51,52]

Neither human nor non-human data exists interrelating hay fever or sinusitis to oxidant exposure. In this disease state, it would appear that the uniformity of expert opinion represented an extrapolation from the assumptions made for asthmatic patients. Whether this explanation is true or not can only be tested by asking the experts the reasons for their virtually identical estimates.

Nitrogen Dioxide

In contradistinction to the uniformity of opinion concerning the dose-response relationships for oxidant exposures, almost all of the estimates for nitrogen dioxide lacked significance. Group agreement did not occur for any values among the normal adult, child, or elderly population groups. This is not surprising since few human studies of the effect of acute exposure to nitrogen dioxide have been performed, and these have usually tested respiratory function rather than clinical response.[3,53-57] Experimental data from these and other relevant studies are summarized in Table 32.

Nakamura had 15 healthy persons inhale 6 to 40 ppm of nitrogen dioxide for five minutes and found that airway resistance increased by 24 percent just after termination of inhalation.[53] Suzuki and Ishikawa had 10 healthy persons inhale 0.7 to 2.0 ppm of nitrogen dioxide for 10 minutes and found that the effective compliance, expiratory and inspiratory resistances did not change immediately after inhalation was discontinued, but did change at 10 minutes post inhalation.[54] According to these data the inspiratory resistance rose by 50 percent on the average, the expiratory resistance rose by 15 percent (average), and the effective compliance decreased by approximately 10 percent. In a similar kind of human experiment Abe observed a post inhalation increase in expiratory and inspiratory flow resistance in healthy adults who were exposed for 10 minutes to 4.0 to 5.0 ppm of nitrogen dioxide.[55] These abnormalities were quite marked. At 30 minutes after exposure the expiratory resistance was increased by 77 percent and the inspiratory resistance by 92 percent. These investigators did not mention patient symptomatology either during or following exposure to nitrogen dioxide. Hence, any prediction as to discomfort, disability, or incapacity in "normals" is of necessity conjectural. The lack of information in regard to nitrogen dioxide induced symptoms undoubtedly accounts for the difference in group agreement between oxidant and nitrogen dioxide dose-response relationships.

Some group agreement occurred in certain estimates for infections such as viral bronchitis, upper respiratory infections and influenza. The

TABLE 32: Summary of Experimental Data on Nitrogen Dioxide Effects Relevant to the Delphi Data

Concentration (ppm)	Exposure Time	Subjects	Effects	Reference
6-40	5 minutes	Human	Increase in airway resistance by 24%	53
0.7-2.0	10 minutes	Human	Expiratory resistance increased by 15%; inspiratory resistance increased by 50%	54
4-5	10 minutes	Human	30 minutes after exposure, expiratory resistance increased by 77%, and inspiratory resistance by 92%	55
25 or higher	< 1 hour	Human	Bronchiolitis and pneumonitis	2, 58
150-200	--	Human	Fatal pulmonary fibrosis	1, 2
> 200	--	Human	Acute pulmonary edema and death	1, 2, 59
3.5	2 hours	Mice	Increased incidence of bacterial pneumonia and death	60
4-5	1 hour	Human	Decrease in arterial partial pressure of O_2; increase in alveolar-arterial O_2 pressure gradient	56, 57

experts predicted that one hour exposures to 3.0 ppm of nitrogen dioxide would cause disability (dyspnea) in 10% of individuals with viral bronchitis and that exposure to 4.0 ppm would cause disability in 50%. The threshold level for this effect in 0% of the population was estimated to be 1.5 ppm. Discomfort due to cough was predicted in 10% of individuals with viral bronchitis following exposure to 2.1 ppm of nitrogen dioxide and in 50% following exposure to 3.5 ppm. Similarly trustworthy estimates in regard to upper respiratory infections were 3.0 ppm for disability in 10% of the population and 3.1 ppm for discomfort (cough) in 50%. A threshold value of 2.45 ppm was agreed upon for incapacity (acute respiratory failure) in influenza and 3.0 ppm for discomfort in 50% of patients with influenza. Acute exposure to nitrogen dioxide is an uncommon occupational hazard of workers manufacturing nitric acid, of farmers (exposed to silage--silo fillers' disease), and of electric arc workers. Although there is a considerable body of information indicating that exposure to nitrogen dioxide enhances susceptibility to infection, it is difficult to use extrapolations from these data as a comparison for the Delphi predictions. Exposure to 25 ppm or higher for periods of less than one hour has resulted in bronchiolitis and pneumonitis.[2,58] Comparably short periods of exposure to 150-200 ppm causes fatal pulmonary fibrosis.[1,2] Higher exposures are associated with acute pulmonary edema and death.[1,2,59] Because these exposures were accidental in nature, the values cited are at best crude estimates of concentration and duration. Experimental studies have confirmed the cause and effect relationship between exposure to nitrogen dioxide and diminished pulmonary resistance to infection.[60-62] Exposure of mice to fixed concentrations of 3.5 ppm of nitrogen dioxide for two hours prior to infection with virulent Klebsiellal organisms results in a significantly increased incidence of bacterial pneumonia and death.[60] Further studies with this murine model have demonstrated that the nitrogen dioxide induced impairment in bacterial resistance is due to injury to the alveolar macrophage system.[61] According to these experimental data the threshold level for the antibacterial defect is 7.0 ppm for a 4-hour exposure and 2.3 ppm for a 17 hour exposure. Exposure to nitrogen dioxide concentrations of 5 ppm or more for 24 hours has been shown to enhance the susceptibility of non-human primates to influenza infection.[62] These studies are in accordance with the opinion of the experts that exposure to nitrogen dioxide enhances pulmonary susceptibility to infection. However, the evidence is too fragmentary to allow quantitation of the dose-response relationship.

Good group agreement was found in the expert estimates of the threshold level for incapacity and disability in 0% of patients with severe chronic obstructive pulmonary disease. Evidence for the validity of these estimates (1.75 ppm - incapacity; 1.30 ppm - disability) has recently been presented by Von Nieding and associates.[56,57] These investigators showed that a one hour exposure to 4 or 5 ppm of nitrogen dioxide would significantly decrease the arterial partial pressure of oxygen and significantly increase the alveolar-arterial oxygen pressure gradient. Confirmation of these data would indicate that the experts' seemingly low estimates of 1.30 or 1.75 ppm were realistic predictions for populations with severe chronic obstructive pulmonary disease. There was little agreement among the experts on the estimates for the various percentages of patients with mild or severe heart disease, asthma, hay fever or sinusitis. This lack of agreement by the experts can be attributed to a paucity of information concerning the dose-response relationship for these population categories.

Carbon Monoxide

Unlike the problem involved with oxidants in which secondary disease such as infection is often the principle complication, carbon monoxide exerts its toxic effect directly by combining with hemoglobin to form carboxyhemoglobin. The high affinity of carbon monoxide for the hemoglobin molecule, 210 times greater than oxygen, results in physiological loss of the oxygen carrying capacity of the blood. In addition to reducing the oxygen carrying capacity of the blood, carboxyhemoglobin interferes with the release of oxygen by the hemoglobin molecule.[63,64] Hypoxia of varying severity is a direct consequence of these two effects. Functional impairment and tissue injury parallel the extent of exposure as this duration determines the degree of hypoxia. Experimental data on CO effects relevant to this study is summarized in Table 33.

TABLE 33: Summary of Experimental Data on Carbon Monoxide Effects Releant to the Delphi Data

Concentration (ppm)	Exposure Time	Subjects	Effects	Reference
1000	--	Human	Vomiting, coma, death	65
500	1 hour	Human	Mild to throbbing headache	65
100	.5-2 hours	Human	Increased COHb from 1% to 5-10%; interference with higher integrative function	66-68
53	1.5 hours	Human	Shortened mean time to angina	69
50	2 hours	Human	Shortened mean time to angina	70
50-100	4 hours	Human	Shortened mean time to angina	71

Because carbon monoxide toxicity is a common medical problem, much research has been performed in patients with clinical illness as well as volunteers. In normal individuals, the toxic effects of carbon monoxide as a result of acute, high level exposure are the following:[65] Concentrations over 1000 ppm typically cause vomiting, coma, and death. Exposure to 500 ppm for one hour will produce a blood concentration of 20% carboxyhemoglobin and cause mild or throbbing headaches. Exposure to 100 ppm increases the blood carboxyhemoglobin level from 11% (normal) to 5-10%. Interference with higher integrative functions such as vigilance, coordination, and psychomotor function has been observed at these levels of carboxyhemoglobin.[66,68] Whether similar impairments of mentation occur at lesser levels of exposure such as 50 ppm (carboxyhemoglobin of less than 5%) is uncertain.

The dose-response estimates of the experts reflect this information. Good group agreement is present for the 10%, 50%, and 90% segments of almost every population category, normal as well as abnormal, in regard to the presence of discomfort (mild headache, errors in cognitive function) at exposure levels of approximately 100 ppm. More precisely, one hour exposures to carbon monoxide levels of 80 ppm will cause discomfort in 10% of children and the elderly, levels of 103-120 ppm will cause discomfort in 50% of children, adults and the elderly and levels of 130 or 140 will cause discomfort in 90% of adults and the elderly. These values are virtually identical to the previously cited results in volunteers.[66-68] There is no group agreement on the estimates for the threshold level. The absence of agreement may reflect the discordance in results of dose-response testing which has been reported by different investigators. It is of interest that the common value even though not agreed upon by the group is very similar to the federal standard of 35 ppm for one hour.

With one exception the dose-response estimates in regard to the presence of disability were non-uniform. Disability was defined as a throbbing headache, confusion, irritability or dizziness. The average estimate tended to be between 100 and 200 ppm. Similarly, with three exceptions which will be subsequently discussed, the estimates for incapacity did not show agreement.

The only population categories with some consensus regarding concentrations of carbon monoxide likely to cause incapacity or disability were severe heart disease and severe chronic pulmonary disease. The experts predicted the occurrence of angina pectoris, arrythmia, coma or convulsions in 50% of individuals with severe heart disease following a one hour exposure to 180 ppm of carbon monoxide. Good agreement also occurred in the prediction that the threshold level for a 0% result in this population category was 60 ppm. Both of these estimates are much below those for all other patient categories. The uniformity in these estimates as opposed to the lack of group consensus for most of the other patient categories can be attributed to the widespread knowledge of Aronow's studies in which angina pectoris and arrythmia's were induced in patients with cardiac conditions who were exposed to 50 or 100 ppm of carbon monoxide.[69,70,71] The group consensus in regard to the threshold for incapacity for 0% population with severe chronic obstructive pulmonary disease can be attributed to a uniform opinion that at least some of these patients are so sensitive to any additional stress that any increase in hypoxia will result in respiratory failure.

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APPENDIX A

QUESTIONNAIRES

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QUESTIONNAIRES FOR PROJECT

"HUMAN HEALTH DAMAGES FROM MOBILE SOURCE AIR POLLUTION"

PHOTOCHEMICAL OXIDANT

The following questions apply to all population categories included in this study. Please use the attached sheets for your answers. The answers should be marked on the graphs and in boxes of appropriate column provided for each question.

(1) Please indicate by an X the pollutant concentrations which if present for one hour cause 90% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 90% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(2) Please indicate by an X the pollutant concentrations which if present for one hour cause 50% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 50% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(3) Please indicate by an X the pollutant concentrations which if present for one hour cause 10% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 10% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(4) Please indicate by an X the pollutant concentrations which if present for one hour cause 0% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 0% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc.

POLLUTANT: PHOTOCHEMICAL OXIDANT

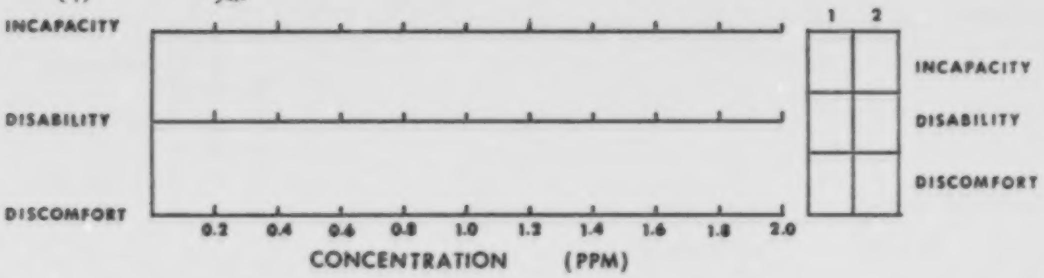
POPULATION CATEGORY:

NORMAL

DEFINITION OF CONDITIONS:

- Incapacity = may precipitate respiratory and cardiac problems, bronchopneumonia
- Disability = headache
- Discomfort = eye irritation, nonproductive coughing, chest tightness

(1) 90%



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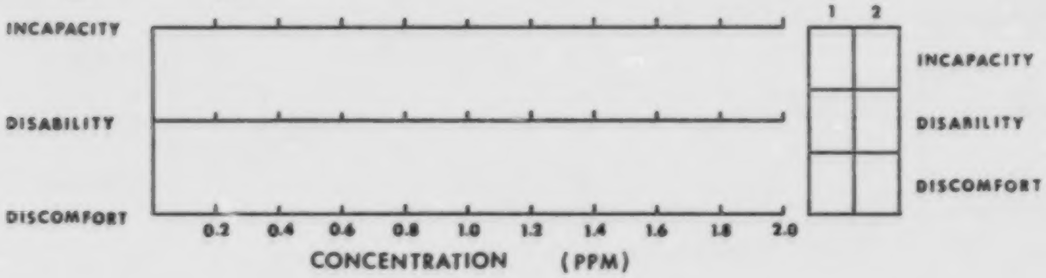

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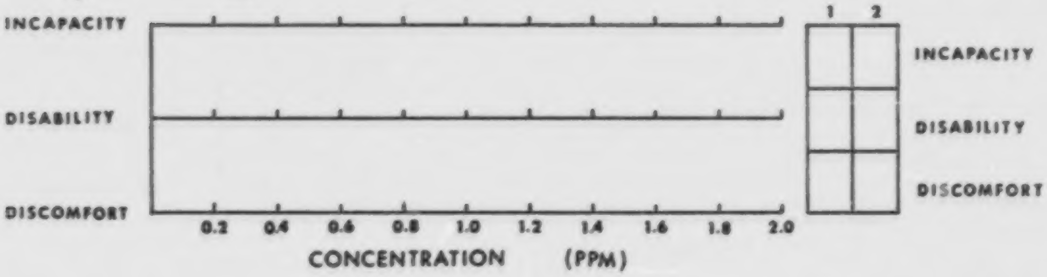

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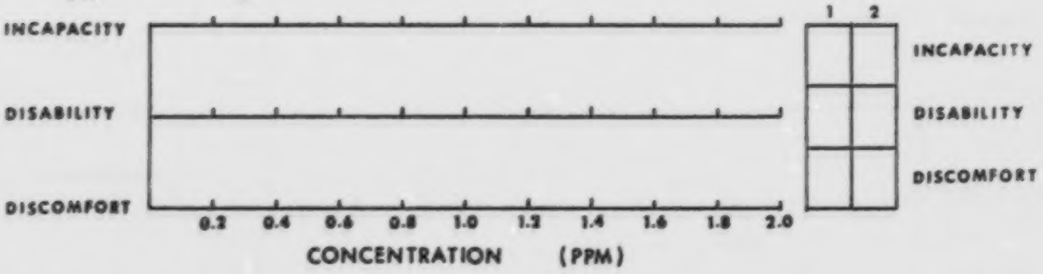


POLLUTANT: PHOTOCHEMICAL OXIDANT

POPULATION CATEGORY:

CHILDREN**

** Children - healthy children of less than 10 years of age.

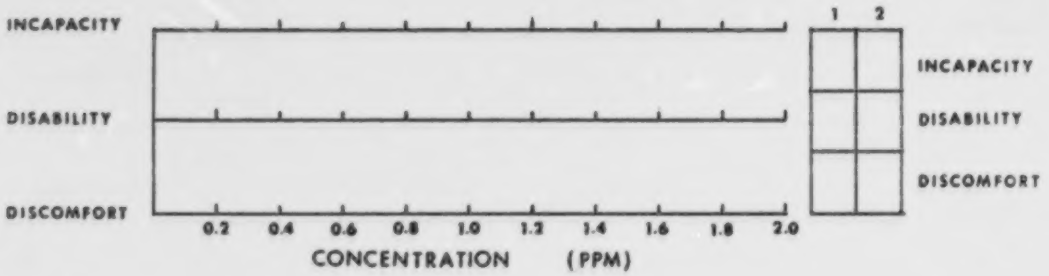
DEFINITION OF CONDITIONS:

* Incapacity = may precipitate respiratory and cardi problems, broncho-pneumonia

* Disability = headache

* Discomfort = eye irritation, non-productive coughing, chest tightness

(1) 90%



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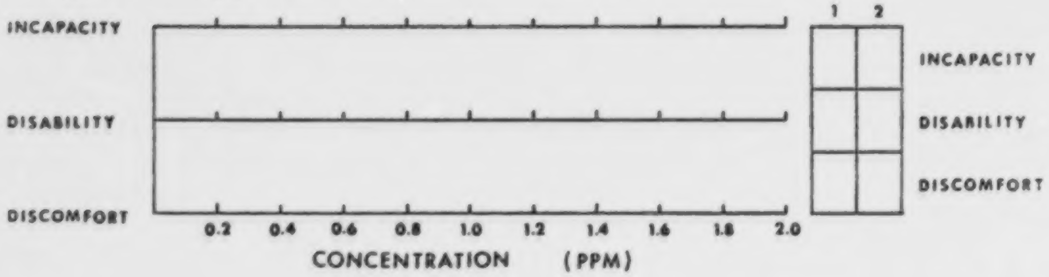

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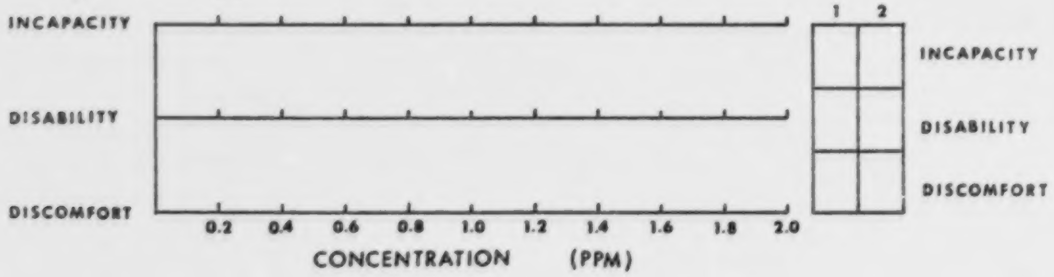

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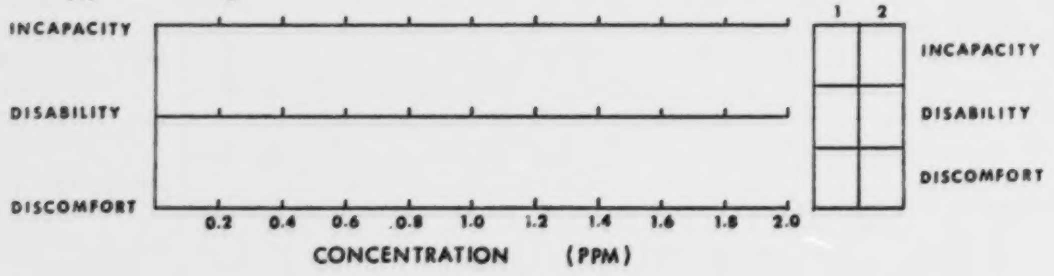

POLLUTANT: PHOTOCHEMICAL OXIDANT

POPULATION CATEGORY:

OLD AGE**

** Old age - patients who have no proven underlining disease but who on an epidemiologic basis are likely to have senile emphysema and arteriosclerotic cardiovascular disease (ASCVD).

DEFINITION OF CONDITIONS:

* Incapacity = acute respiratory failure

* Disability = bronchitis

* Discomfort = hyspnea

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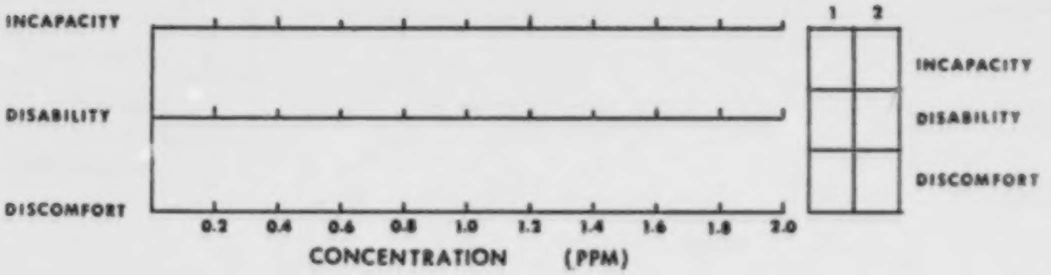
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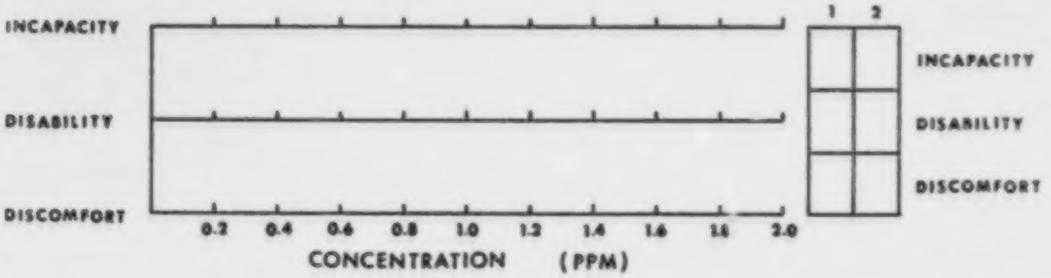
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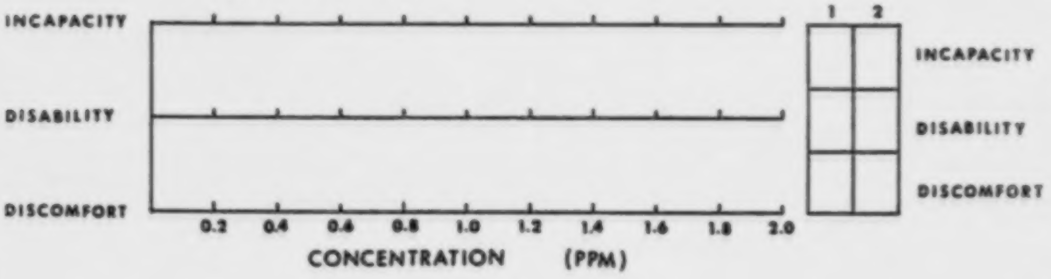
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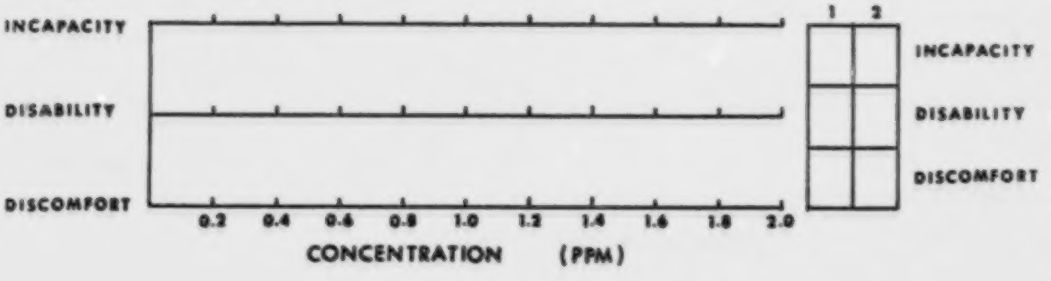
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POLLUTANT: PHOTOCHEMICAL OXIDANT

POPULATION CATEGORY:

HEART CONDITION, MILD**

** Heart condition due to any etiology such as arteriosclerotic cardiovascular disease (ASCVD), rheumatic heart disease, hypertension, ASCVD without evidence of congestive heart failure.

DEFINITION OF CONDITIONS:

- * Incapacity = pulmonary edema
- * Disability = congestive heart failure
- * Discomfort = dyspnea

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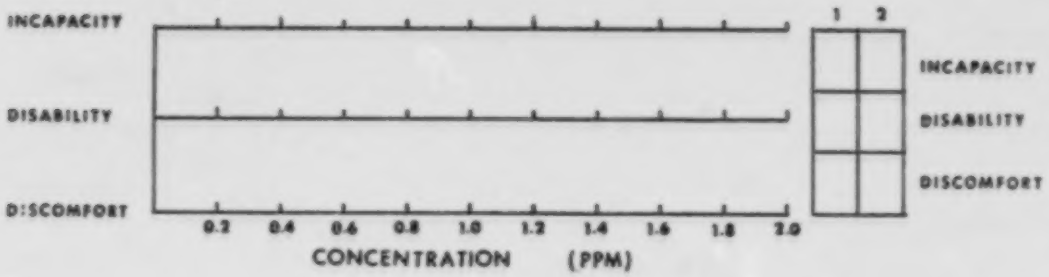

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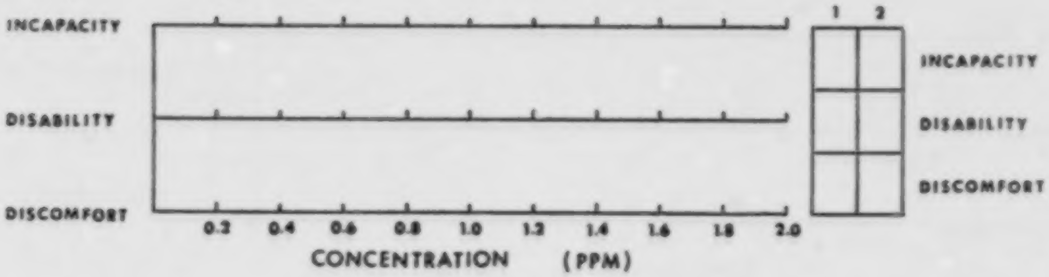

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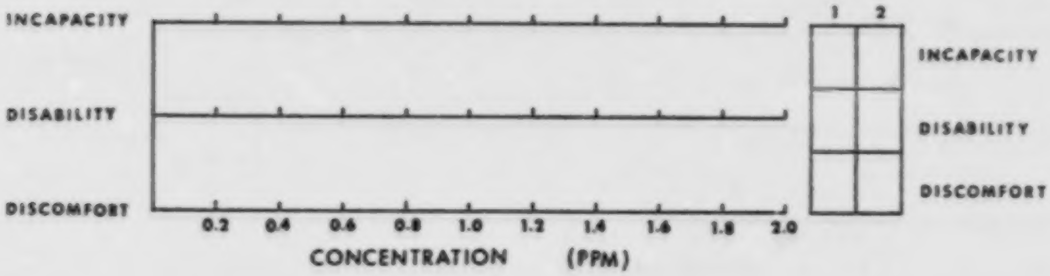

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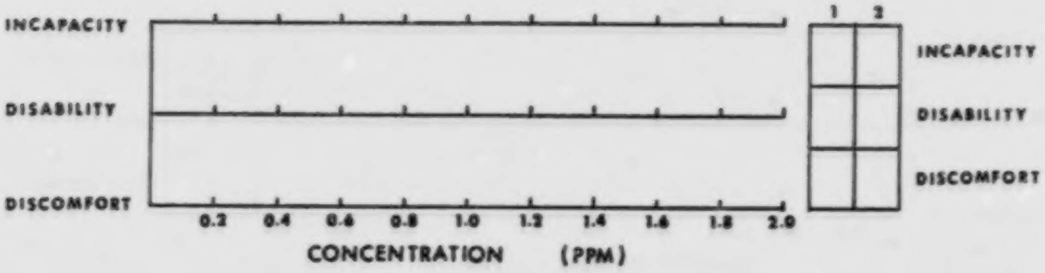

POLLUTANT: PHOTOCHEMICAL OXIDANT

POPULATION CATEGORY:

HEART CONDITION, SEVERE**

** Heart condition due to any etiology such as arteriosclerotic cardiovascular disease (ASCVD), hypertension, rheumatic heart disease with clinical evidence of heart failure.

DEFINITION OF CONDITIONS:

- * Incapacity - angina or a myocardial infarction
- * Disability = pulmonary edema
- * Discomfort = worsening congestive heart failure

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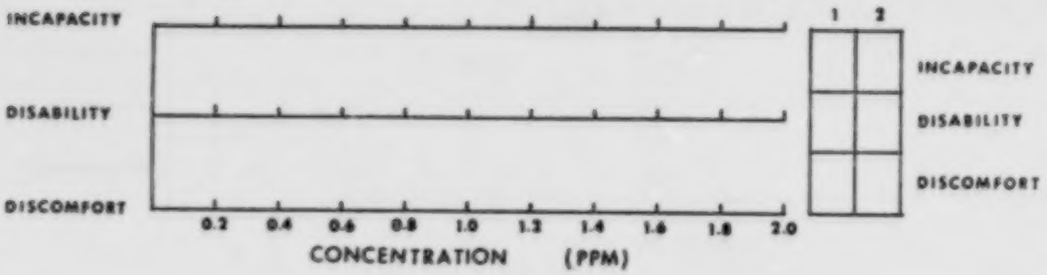

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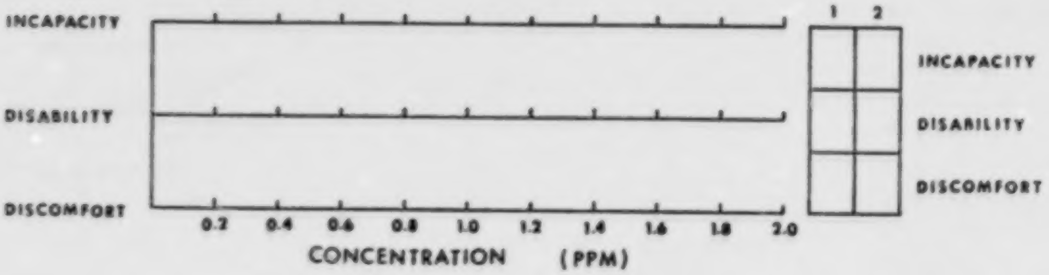

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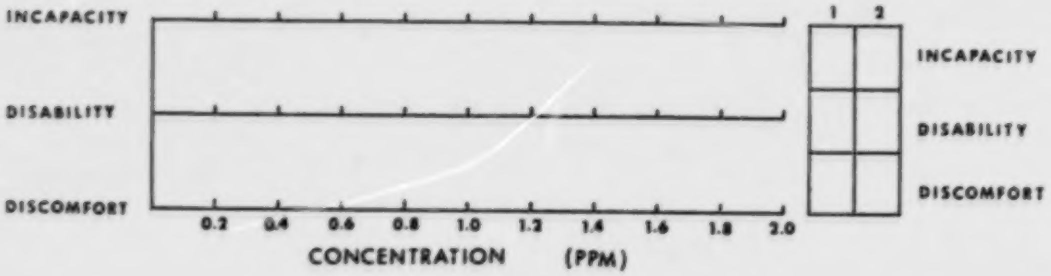

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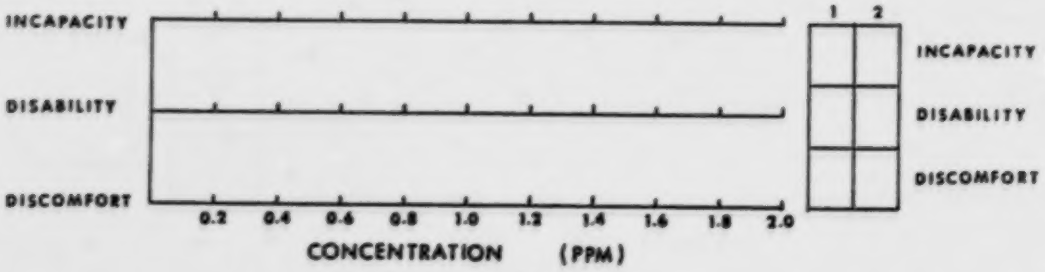


POLLUTANT: PHOTOCHEMICAL OXIDANT

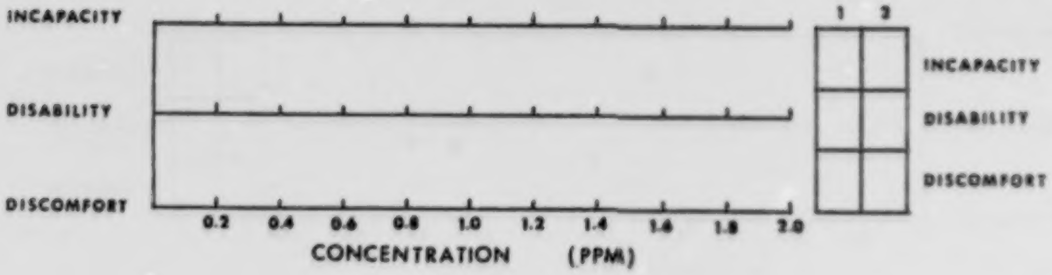
POPULATION CATEGORY:

HAY FEVER, SINUSITIS

DEFINITION OF CONDITIONS:

* Incapacity = nasal or sinus drainage and headache
* Disability = nasal or sinus drainage
* Discomfort = nasal or sinus discomfort

(1) 90%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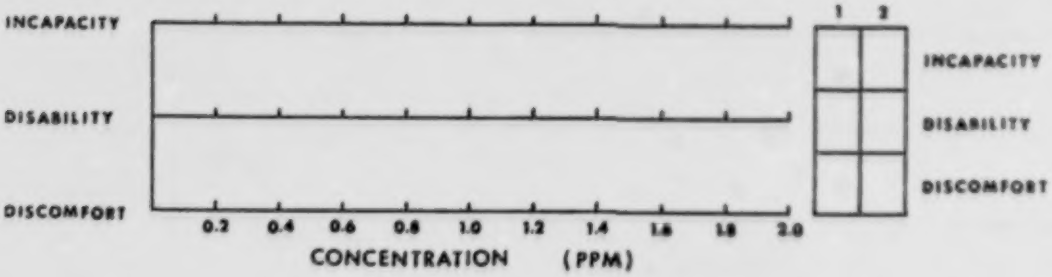
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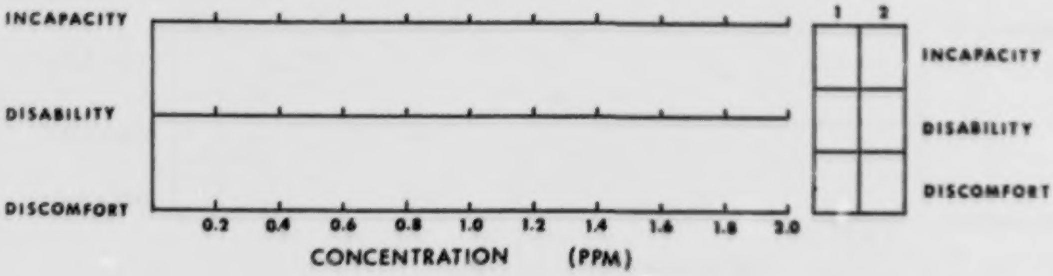
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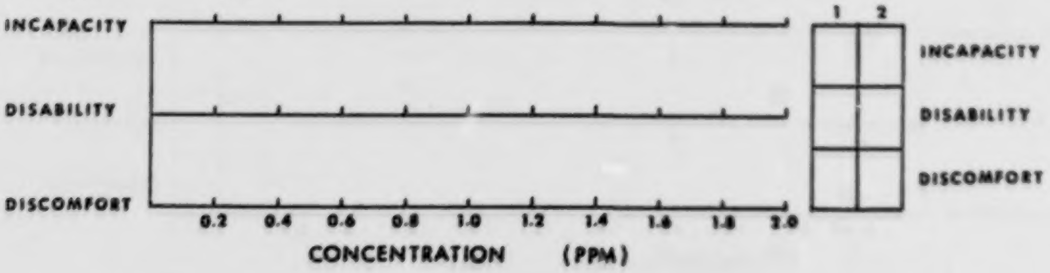
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POLLUTANT: PHOTOCHEMICAL OXIDANT

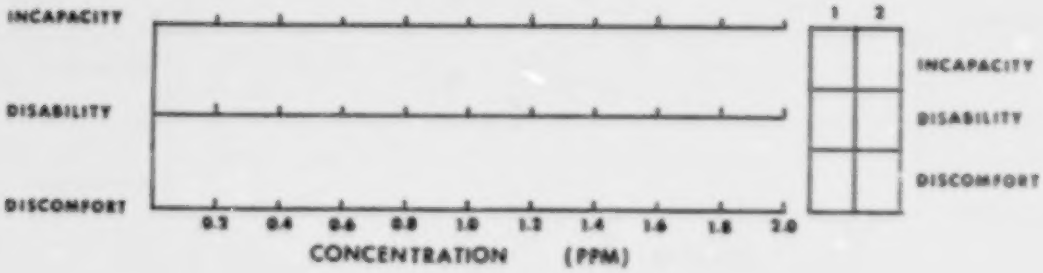
POPULATION CATEGORY:

INFLUENZA

DEFINITION OF CONDITIONS:

- Incapacity = superimposed bacterial pneumonia
- Disability = dyspnea
- Discomfort = increased cough and pleuritic pain

(1) 90%



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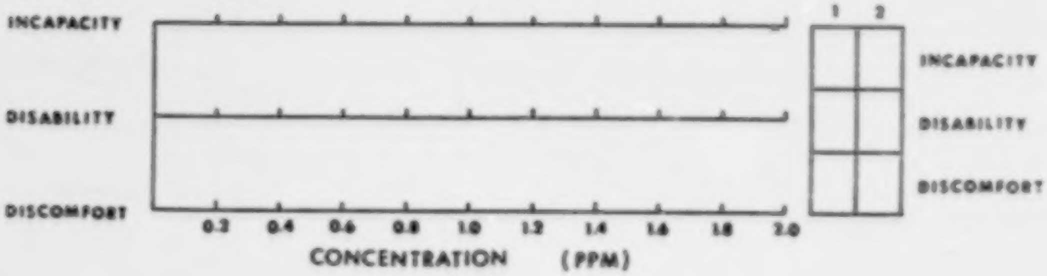

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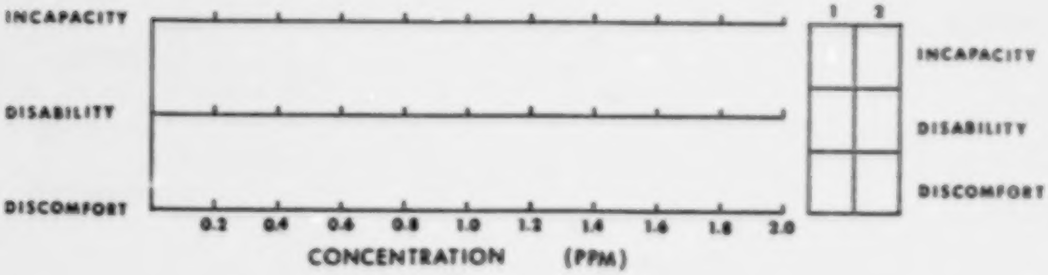

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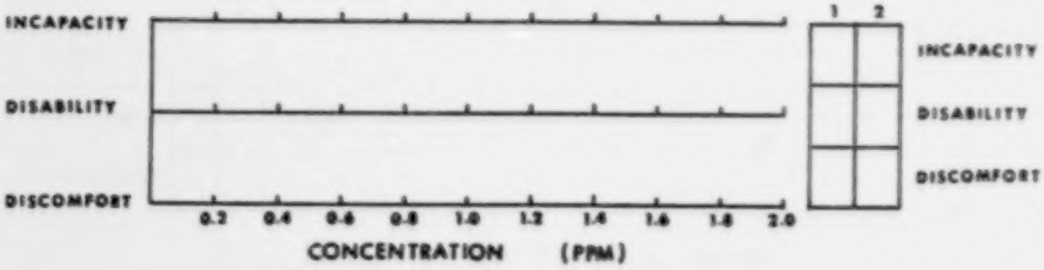


POLLUTANT: PHOTOCHEMICAL OXIDANT

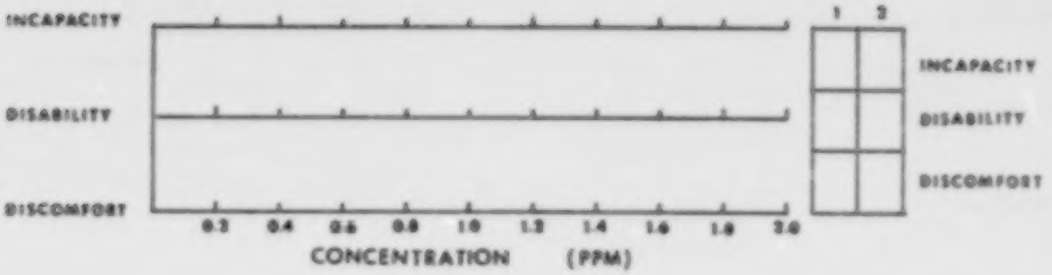
POPULATION CATEGORY:

UPPER RESPIRATORY INFECTION

DEFINITION OF CONDITIONS:

- Incapacity = secondary bacterial infection
- Disability = need medication and rest
- Discomfort = worsening symptoms

(1) 90%



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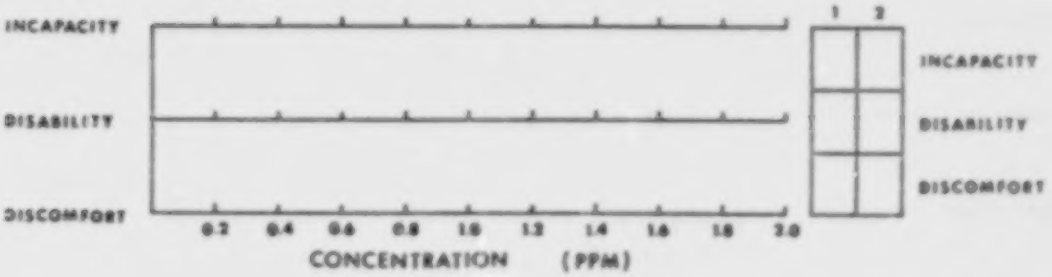

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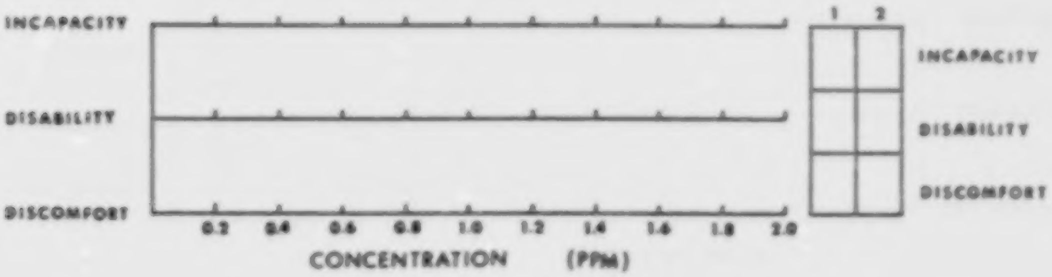

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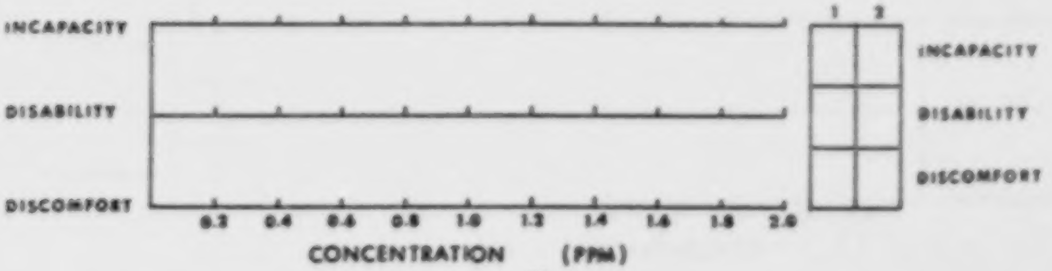
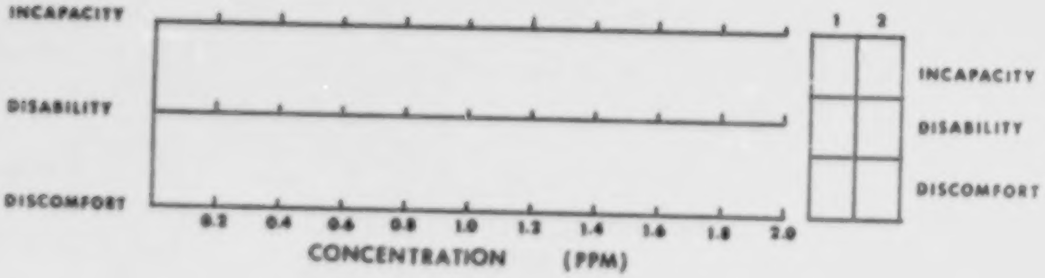


POLLUTANT: PHOTOCHEMICAL OXIDANT

POPULATION CATEGORY:
ASTHMA

DEFINITION OF CONDITIONS:
- Incapacity = status asthmaticus
- Disability = asthmatic attack
- Discomfort = dyspnea

(1) 90%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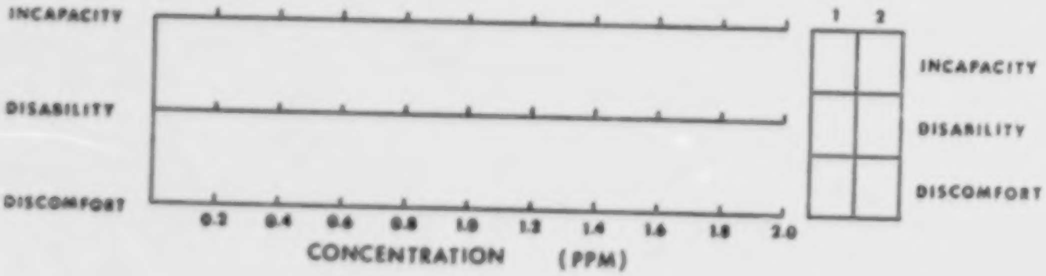
DISCOMFORT

(2) 50%


INCAPACITY
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0.2
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1.2
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CONCENTRATION (PPM)
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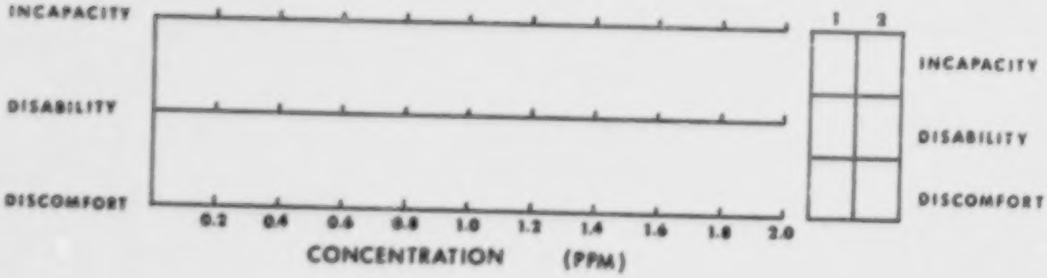
INCAPACITY
DISABILITY
DISCOMFORT

(3) 10%


INCAPACITY
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CONCENTRATION (PPM)
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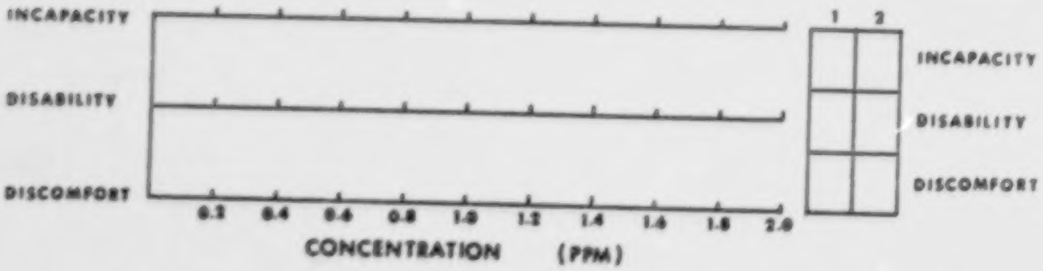
DISABILITY
DISCOMFORT

(4) 0%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CONCENTRATION (PPM)
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INCAPACITY
DISABILITY
DISCOMFORT

POLLUTANT: PHOTOCHEMICAL OXIDANT

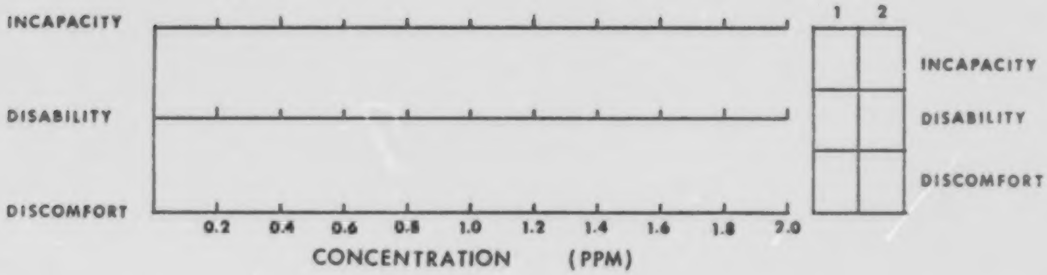
POPULATION CATEGORY:

ACUTE VIRIAL BRONCHITIS

DEFINITION OF CONDITIONS:

- Incapacity = acute respiratory failure
- Disability = dyspnea
- Discomfort = cough

(1) 90%



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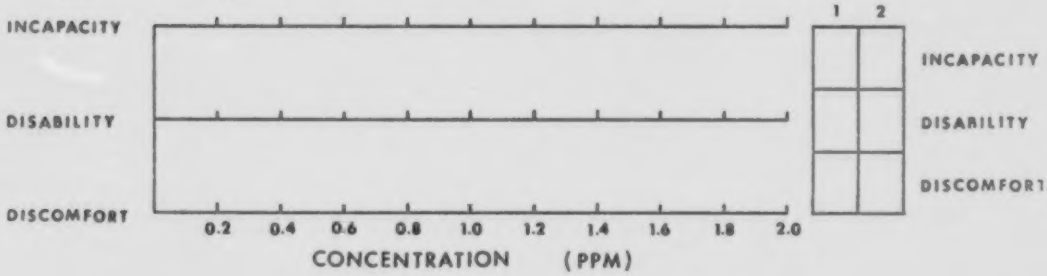

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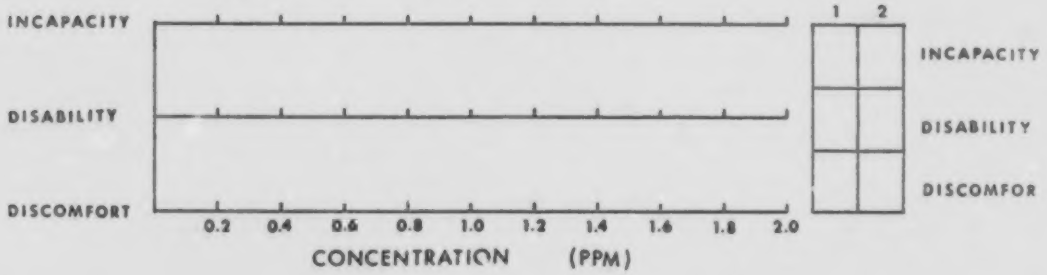

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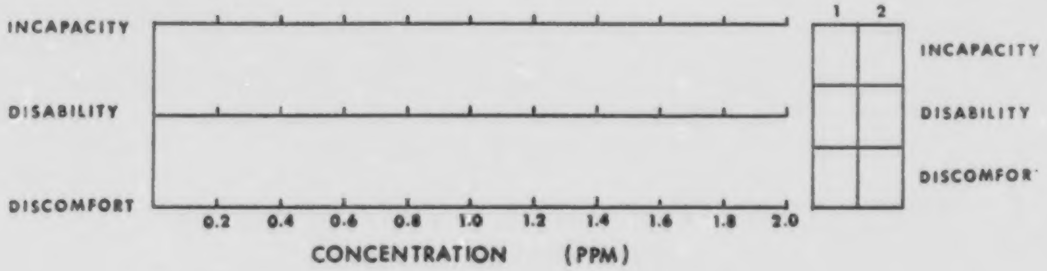


POLLUTANT: PHOTOCHEMICAL OXIDANT

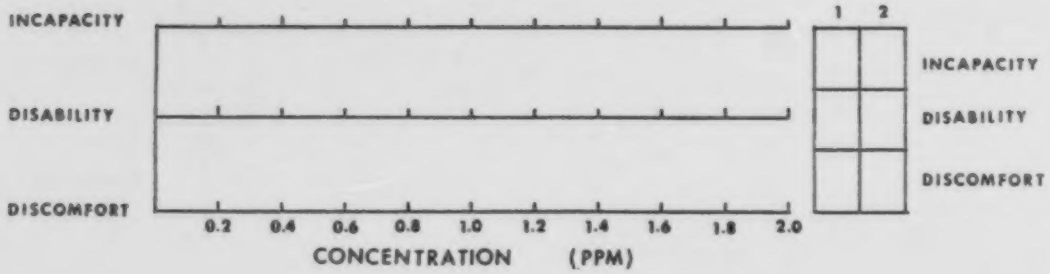
POPULATION CATEGORY:

ACUTE BACTERIAL PNEUMONIA

DEFINITION OF CONDITIONS:

- Incapacity = acute respiratory failure
- Disability = dyspnea
- Discomfort = cough

(1) 90%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CONCENTRATION (PPM)
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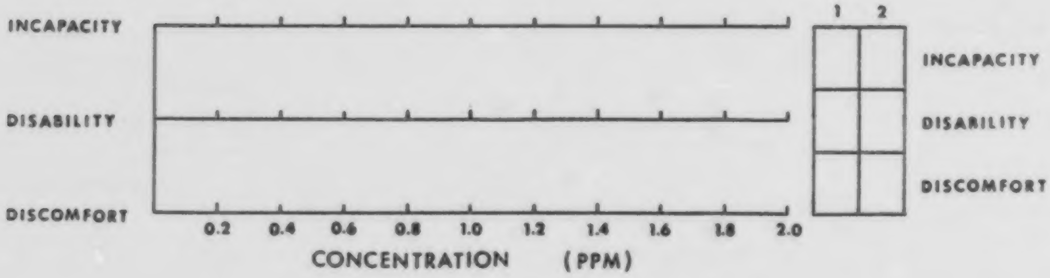
INCAPACITY
DISABILITY
DISCOMFORT

(2) 50%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CONCENTRATION (PPM)
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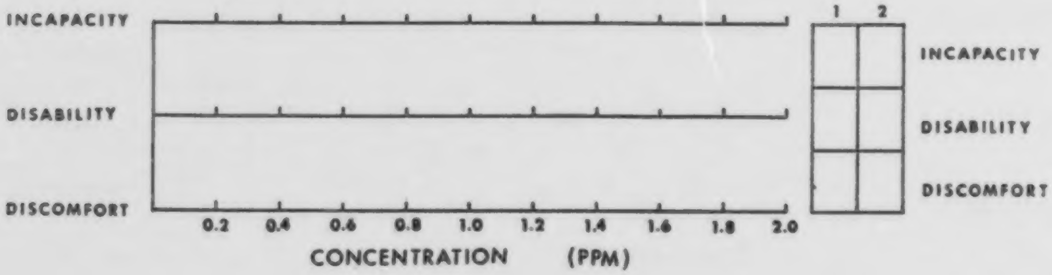
INCAPACITY
DISABILITY
DISCOMFORT

(3) 10%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CONCENTRATION (PPM)
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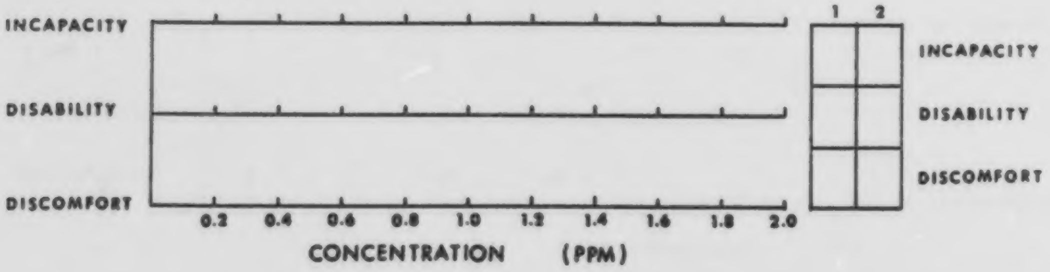
INCAPACITY
DISABILITY
DISCOMFORT

(4) 0%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2.0
CONCENTRATION (PPM)
1
2
INCAPACITY
DISABILITY
DISCOMFORT

POLLUTANT: PHOTOCHEMICAL OXIDANT

POPULATION CATEGORY:

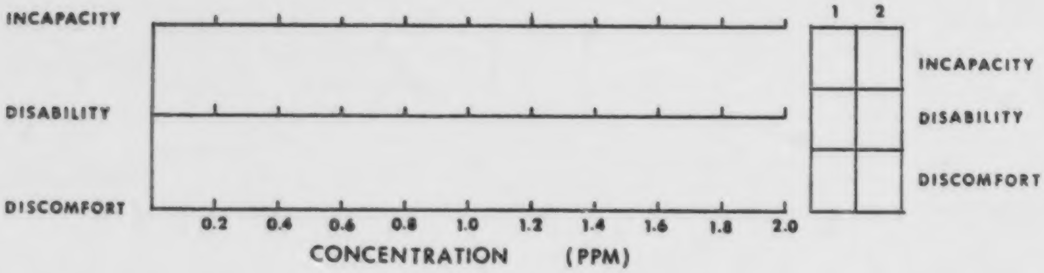
CHRONIC RESPIRATORY DISEASES**

** Chronic respiratory diseases of a non-infectious nature such as pneumoconiosis, or sarcoidosis.

DEFINITION OF CONDITIONS:

- Incapacity = pneumonia
- Disability = respiratory infection
- Discomfort = dyspnea

(1) 90%



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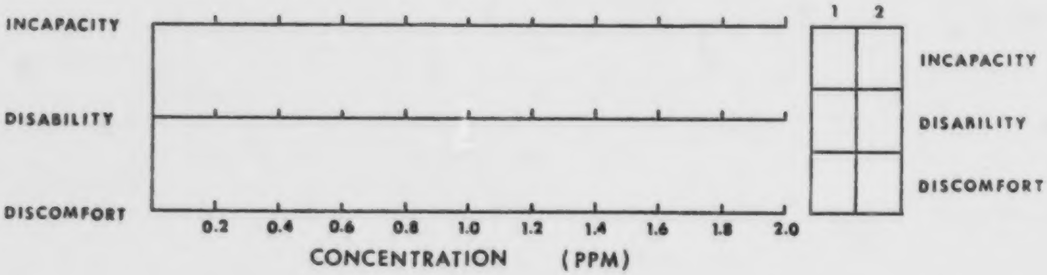

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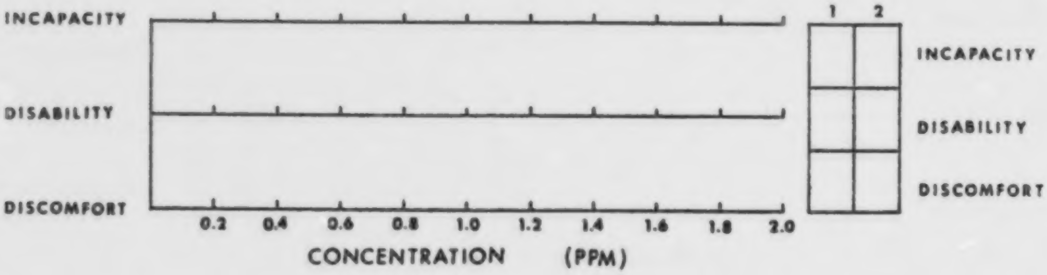

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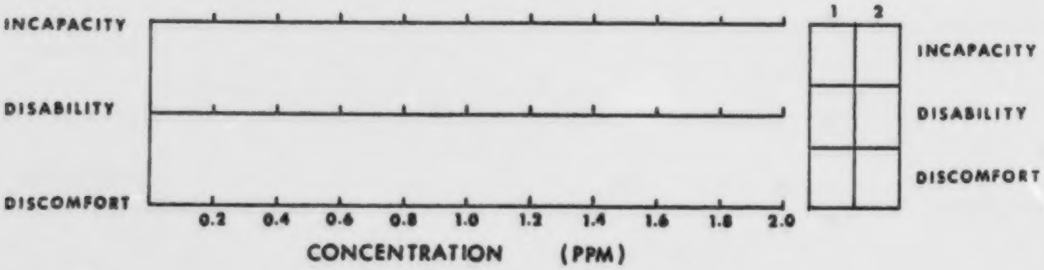


POLLUTANT: PHOTOCHEMICAL OXIDANT

POPULATION CATEGORY:

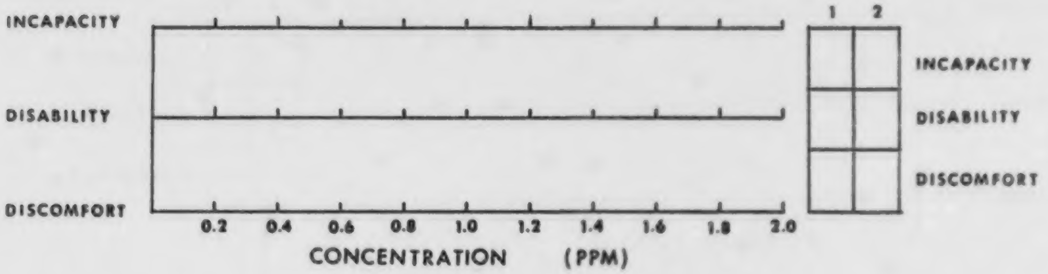
MILD CHRONIC OBSTRUCTIVE LUNG DISEASE**

** Patients with mild chronic obstructive pulmonary disease are defined as individuals who expectorates purulent sputum for periods of at least three months during each year.

DEFINITION OF CONDITIONS:

- Incapacity = broncho-pneumonia, cor pulmonale
- Disability = exacerbation of bronchitis, fever and increased sputum production and chest pain
- Discomfort = dyspnea

(1) 90%



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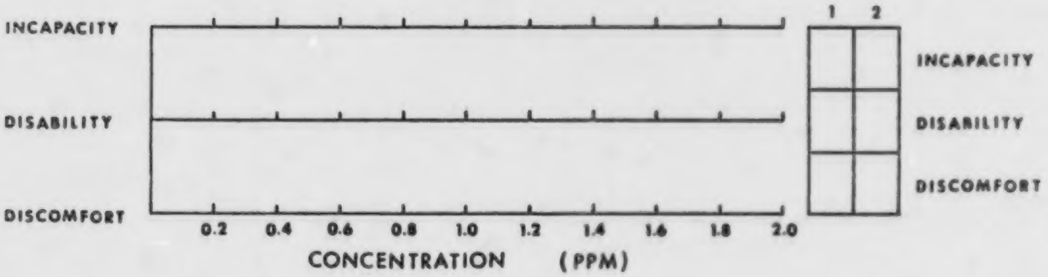

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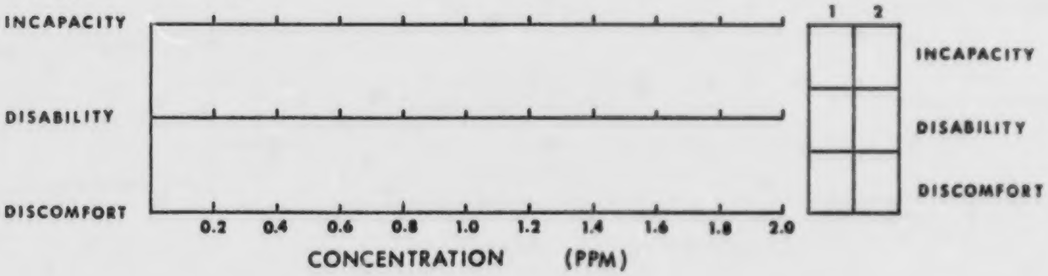

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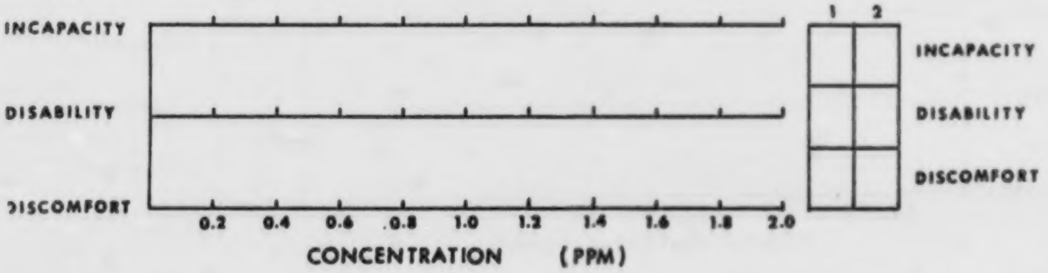


POLLUTANT: PHOTOCHEMICAL OXIDANT

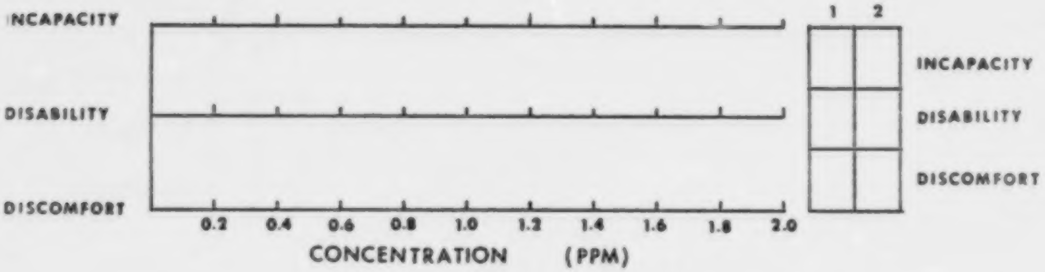
POPULATION CATEGORY:
SEVERE CHRONIC OBSTRUCTIVE LUNG DISEASE**

** Patients with severe chronic obstructive pulmonary disease are defined as individuals who in addition to expectorating purulent sputum for periods of at least three months during each year, also, have a diminished FEV_1 and persistent hypoxemia with arterial blood oxygen tensions of <60 mm hg.

DEFINITION OF CONDITIONS:

- Incapacity = broncho-pneumonia, cor pulmonale
- Disability = exacerbation of bronchitis, fever and increased sputum production and chest pain
- Discomfort = dyspnea

(1) 90%



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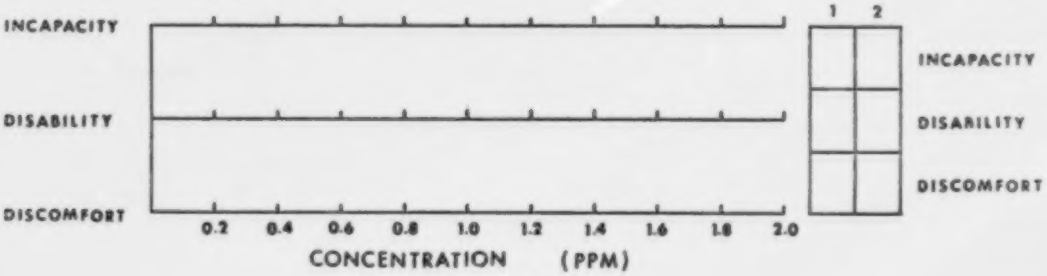
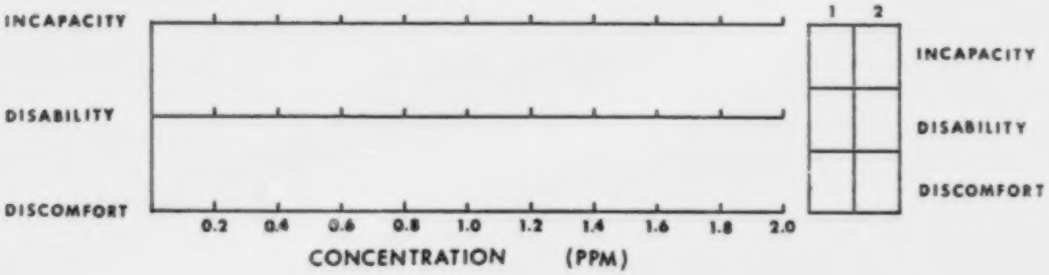


(3) 10%



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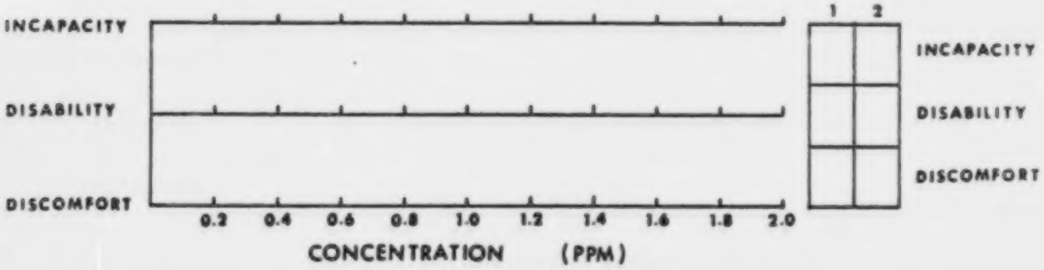


QUESTIONNAIRES FOR PROJECT
"HUMAN HEALTH DAMAGES FROM MOBILE SOURCE AIR POLLUTION"

NITROGEN DIOXIDE

The following questions apply to all population categories included in this study. Please use the attached sheets for your answers. The answers should be marked on the graphs and in boxes of appropriate column provided for wach question.

(1) Please indicate by an X the pollutant concentrations which if present for one hour cause 90% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 90% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(2) Please indicate by an X the pollutant concentrations which if present for one hour cause 50% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 50% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(3) Please indicate by an X the pollutant concentrations which if present for one hour cause 10% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 10% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(4) Please indicate by an X the pollutant concentrations which if present for one hour cause 0% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 0% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc.

POLLUTANT: NITROGEN DIOXIDE

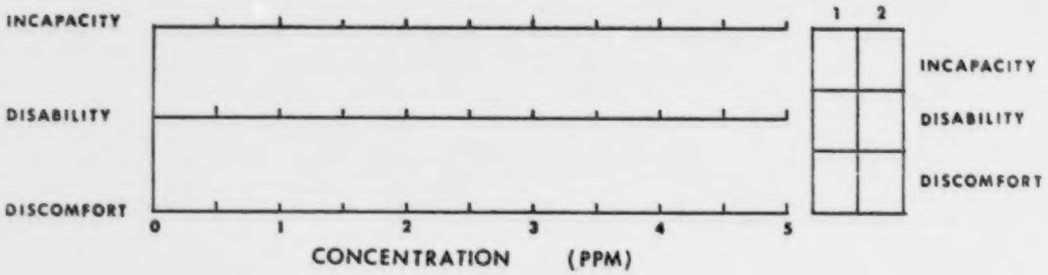
POPULATION CATEGORY:

NORMAL

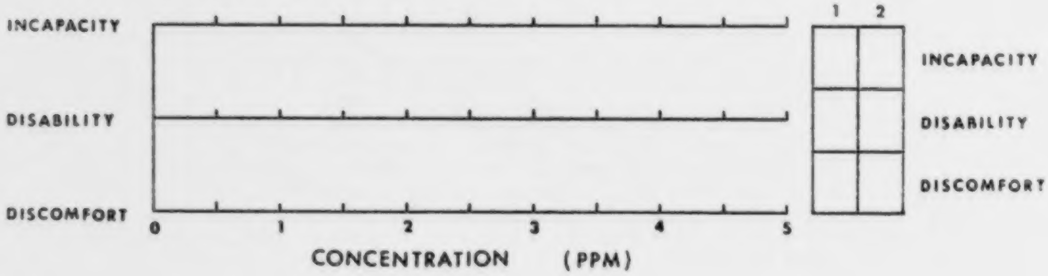
DEFINITION OF CONDITIONS:

- Incapacity = may precipitate respiratory and cardiac problems, broncho-pneumonia
- Disability = headache
- Discomfort = eye irritation, non-productive coughing, chest tightness

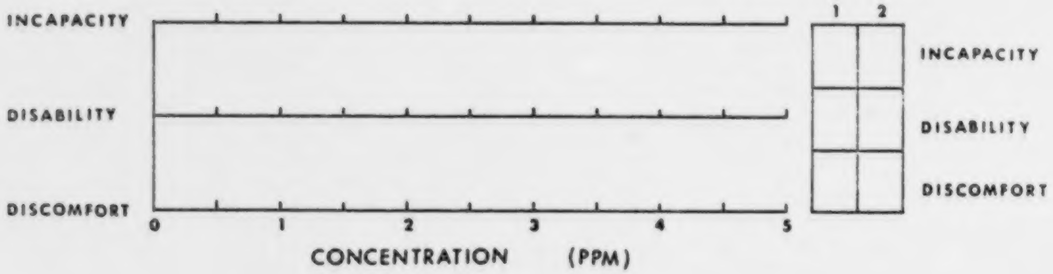
(1) 90%



(2) 50%



(3) 10%



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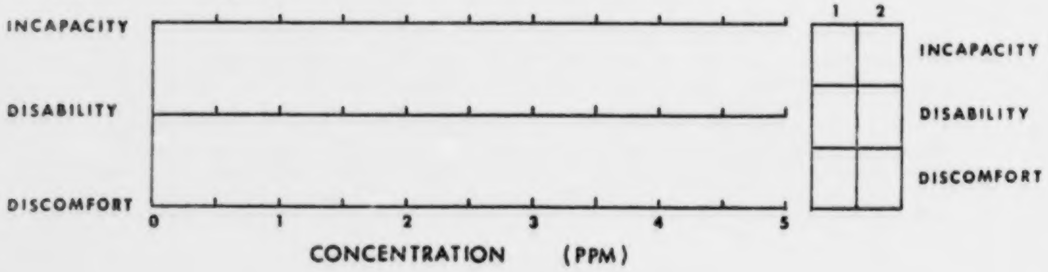


POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

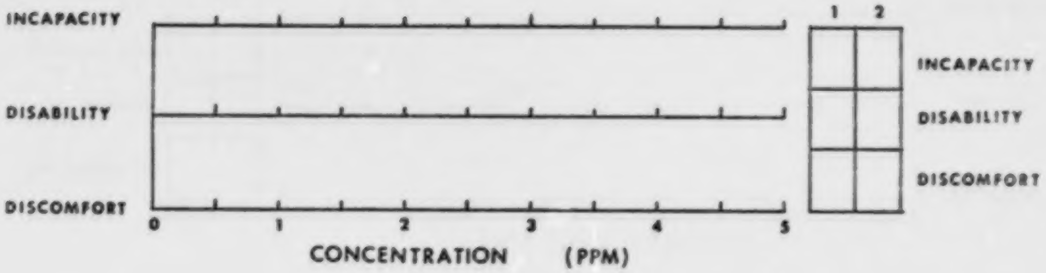
CHILDREN**

** Children - healthy children of less than 10 years of age.

DEFINITION OF CONDITIONS:

- Incapacity = may precipitate respiratory and cardiac problems, broncho-pneumonia
- Disability = headache
- Discomfort = eye irritation, non-productive coughing, chest tightness

(1) 90%



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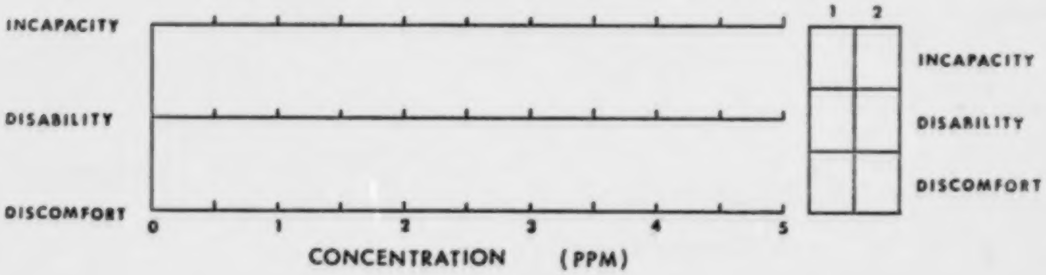

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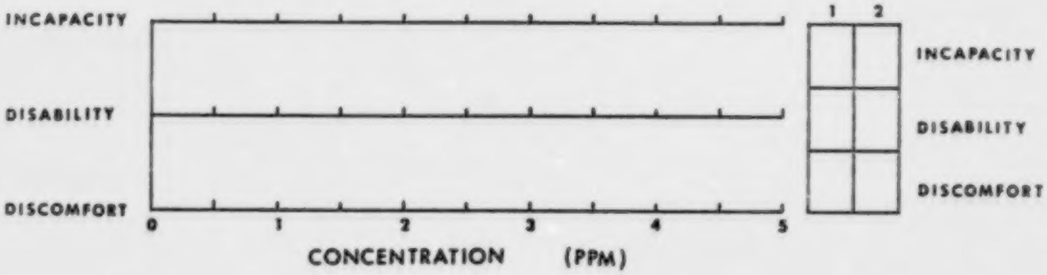

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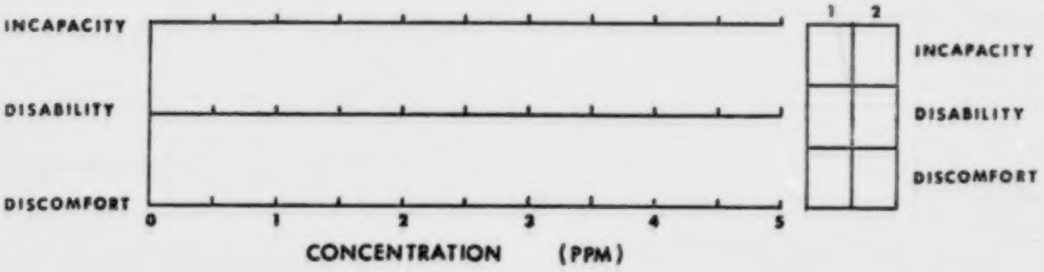


POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

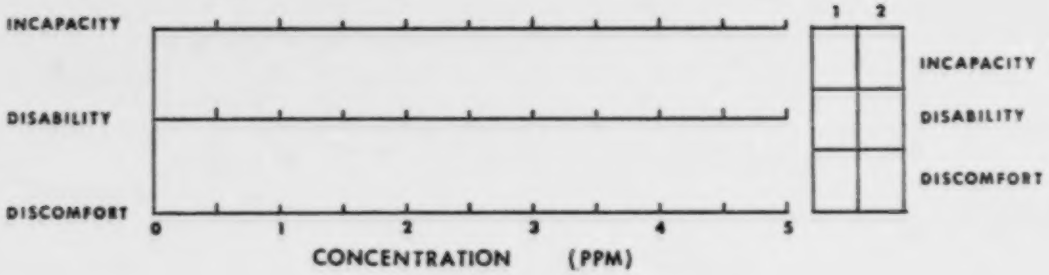
OLD AGE**

** Old age - patients who have no proven underlining disease but who on an epidemiologic basis are likely to have senile emphysema and arteriosclerotic cardiovascular disease (ASCVD).

DEFINITION OF CONDITIONS:

- Incapacity = acute respiratory failure
- Disability = bronchitis
- Discomfort = dyspnea

(1) 90%



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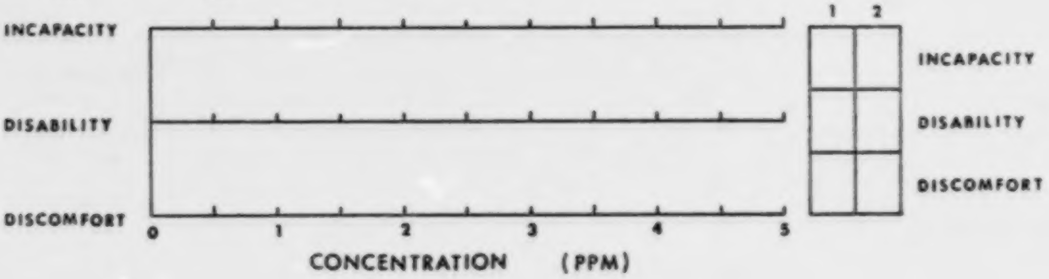

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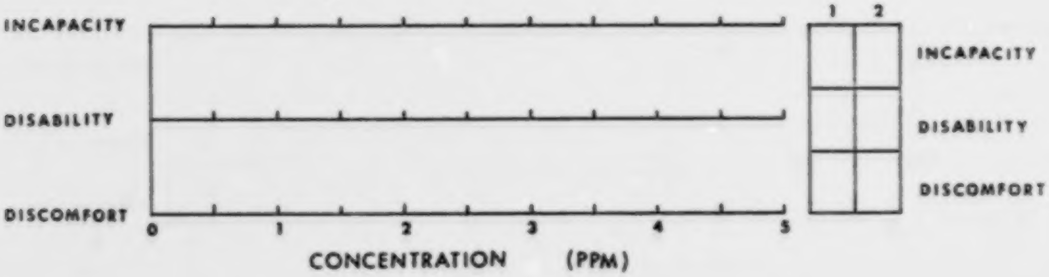

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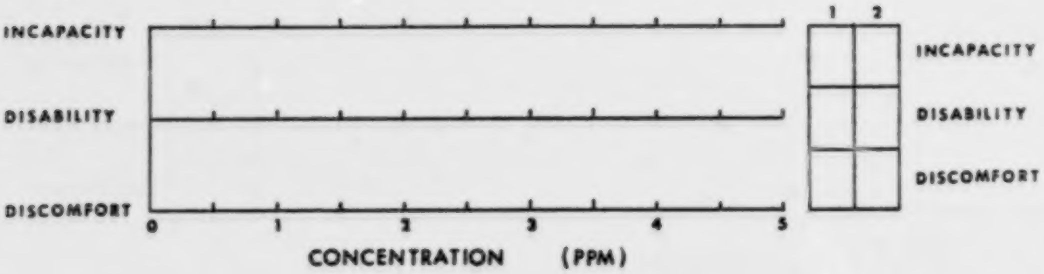


POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

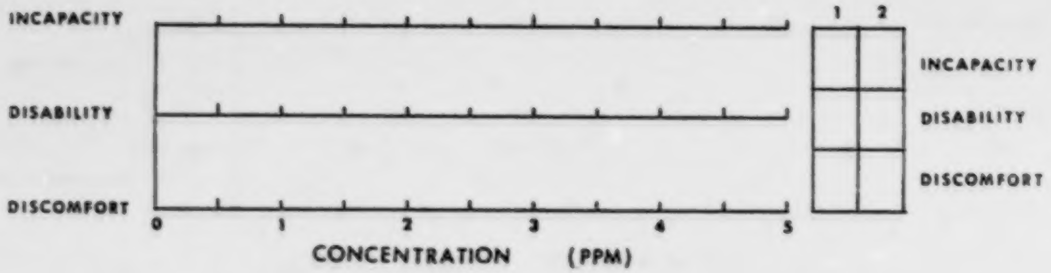
HEART CONDITION, MILD**

** Heart condition due to any etiology such as arteriosclerotic cardiovascular disease (ASCVD), rheumatic heart disease, hypertension, ASCVD without evidence of congestive heart failure.

DEFINITION OF CONDITIONS:

- Incapacity = pulmonary edema
- Disability = congestive heart failure
- Discomfort - dyspnea

(1) 90%



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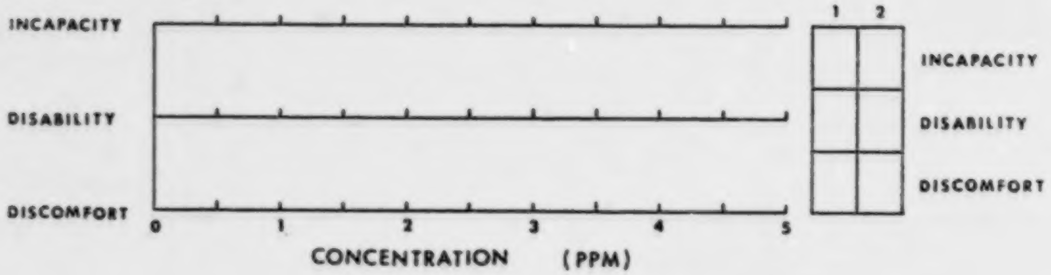

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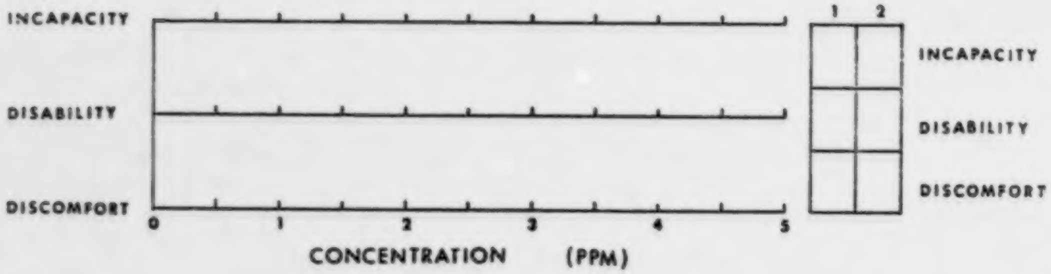

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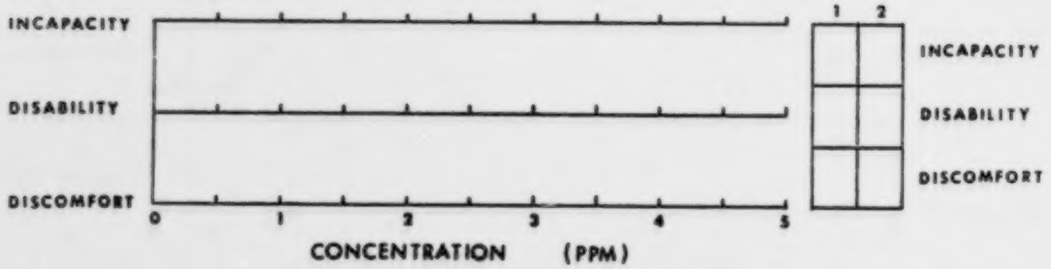


POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

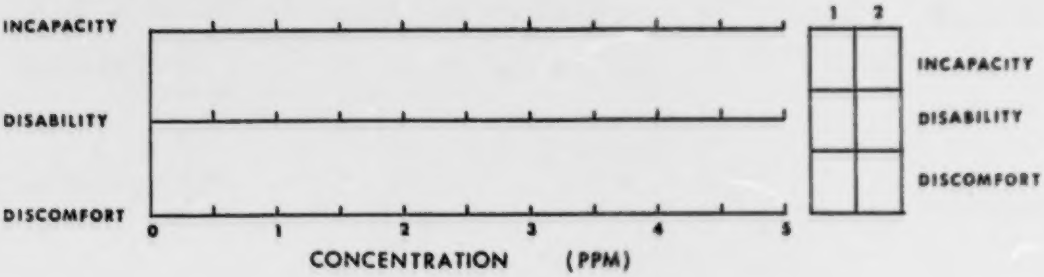
HEART CONDITION, SEVERE**

** Heart condition due to any etiology such as arteriosclerotic cardiovascular disease (ASCVD), hypertension, rheumatic heart disease with clinical evidence of heart failure.

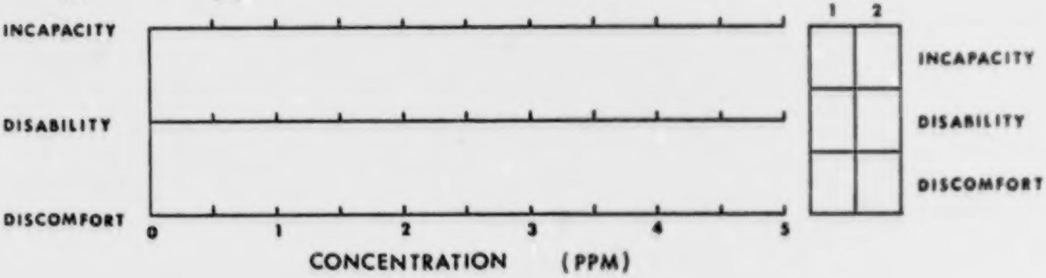
DEFINITION OF CONDITIONS:

* Incapacity = angina or a myocardial infarction
* Disability = pulmonary edema
* Discomfrot = worsening congestive heart failure

(1) 90%



(2) 50%



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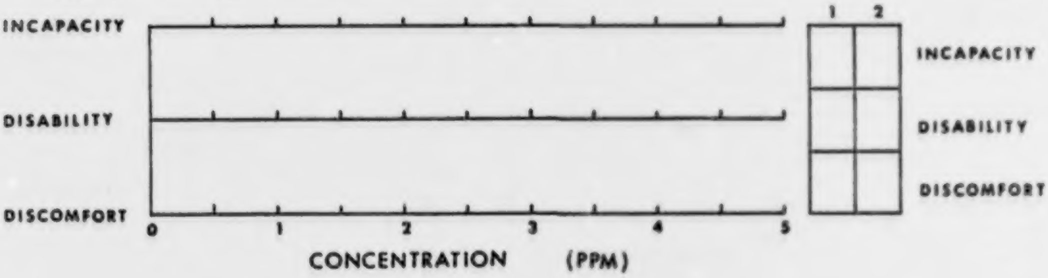

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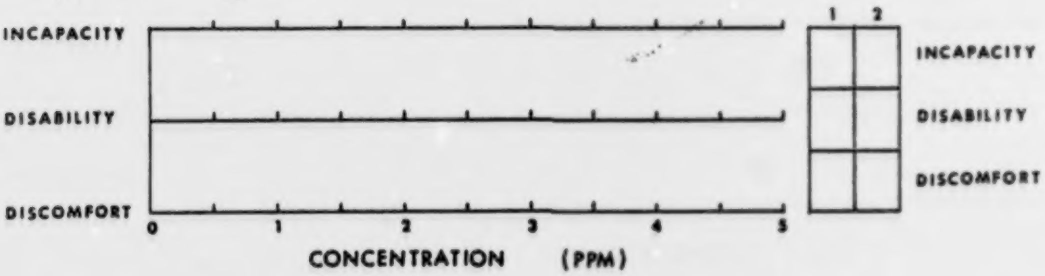


POLLUTANT: NITROGEN DIOXIDE

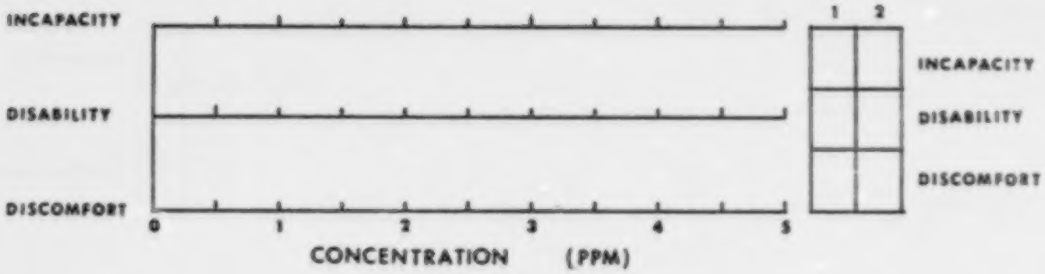
POPULATION CATEGORY:

HAY FEVER, SINUSITIS

DEFINITION OF CONDITIONS:

- Incapacity = nasal or sinus drainage and headache
- Disability = nasal or sinus drainage
- Discomfort = nasal or sinus discomfort

(1) 90%


INCAPACITY
DISABILITY
DISCOMFORT
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CONCENTRATION (PPM)
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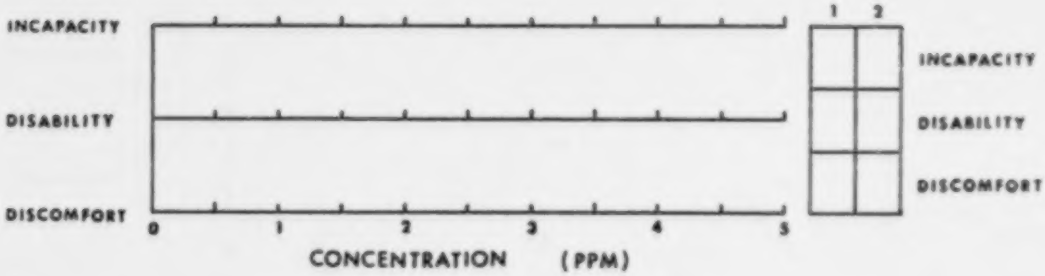
INCAPACITY
DISABILITY
DISCOMFORT

(2) 50%


INCAPACITY
DISABILITY
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CONCENTRATION (PPM)
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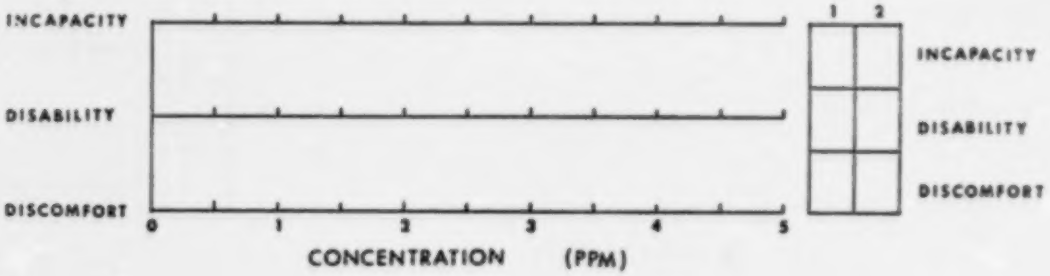
INCAPACITY
DISABILITY
DISCOMFORT

(3) 10%


INCAPACITY
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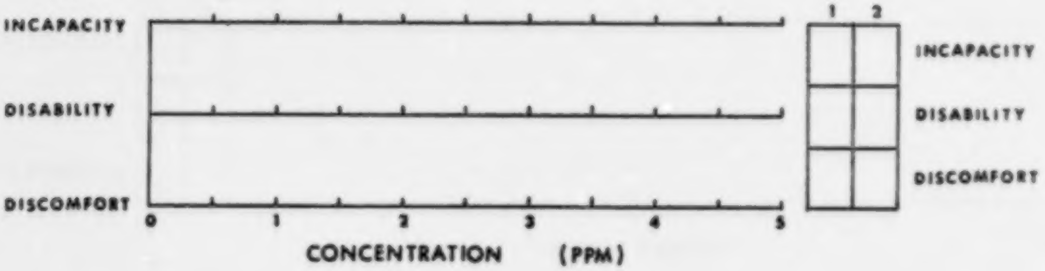
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DISABILITY
DISCOMFORT

POLLUTANT: NITROGEN DIOXIDE

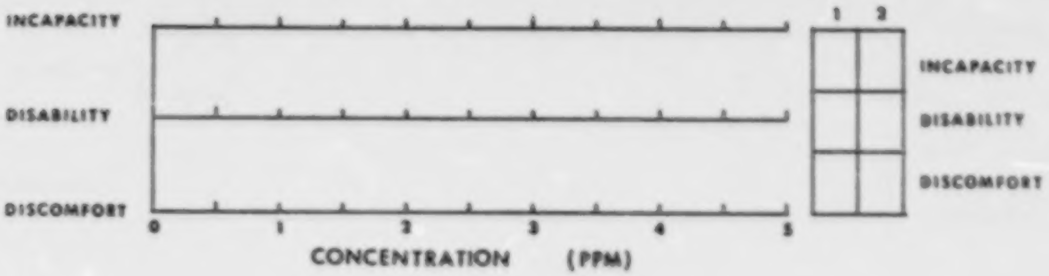
POPULATION CATEGORY:

INFLUENZA

DEFINITION OF CONDITIONS:

- Incapacity = superimposed bacterial pneumonia
- Disability = dyspnea
- Discomfort = increased cough and pleuritic pain

(1) 90%



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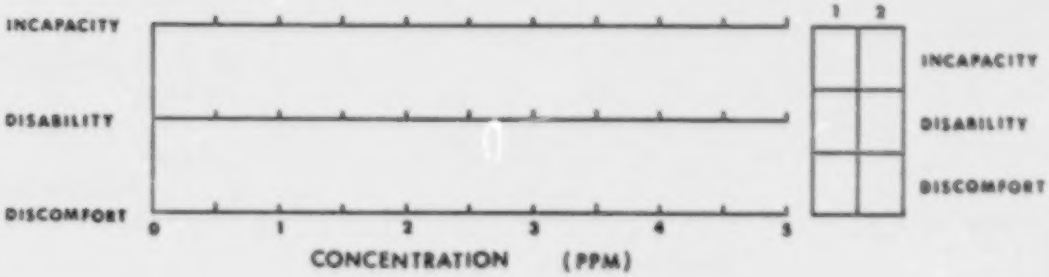

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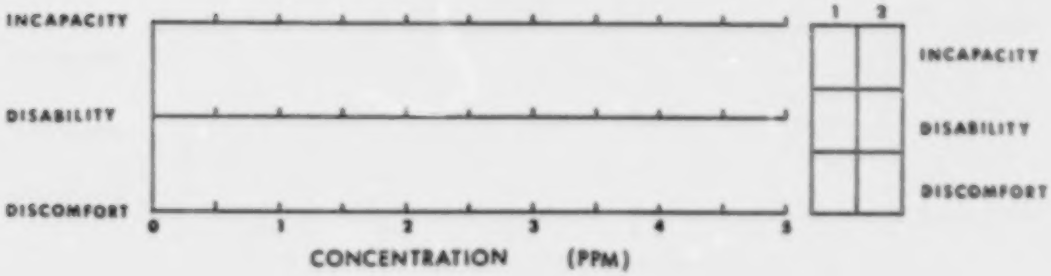

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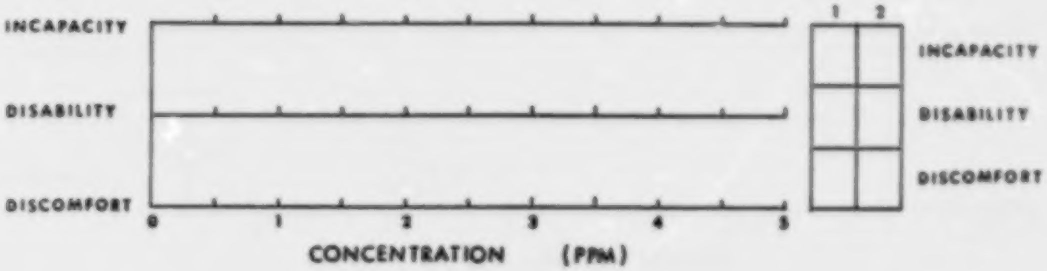


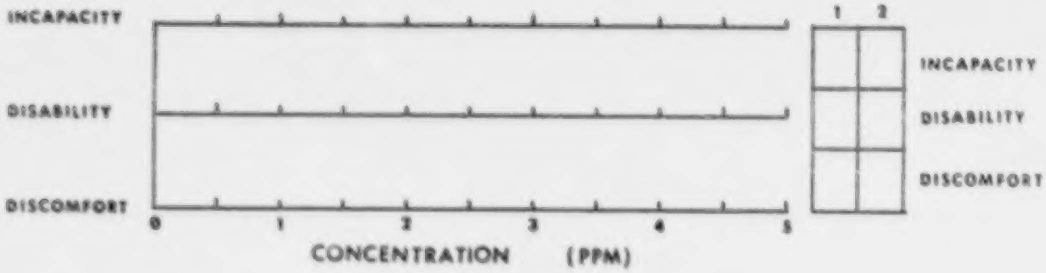
POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:
UPPER RESPIRATORY INFECTION

DEFINITION OF CONDITIONS:

- Incapacity = secondary bacterial infection
- Disability = need medication and rest
- Discomfort = worsening symptoms

(1) 90%



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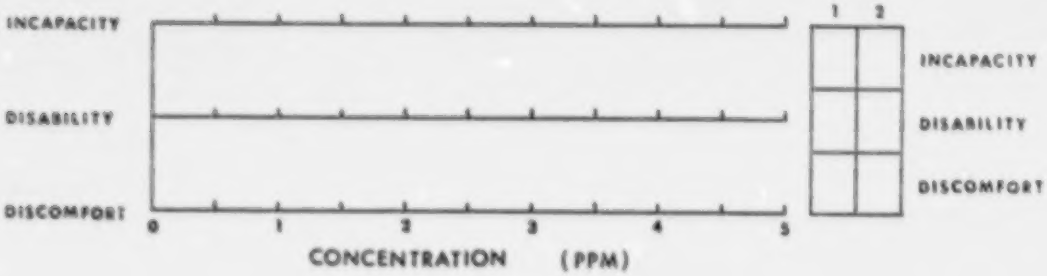

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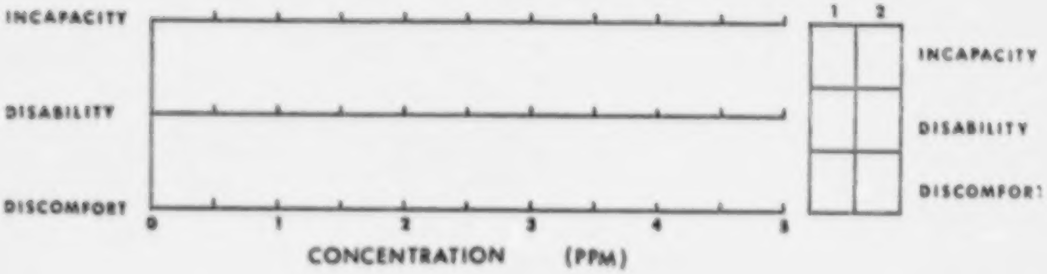

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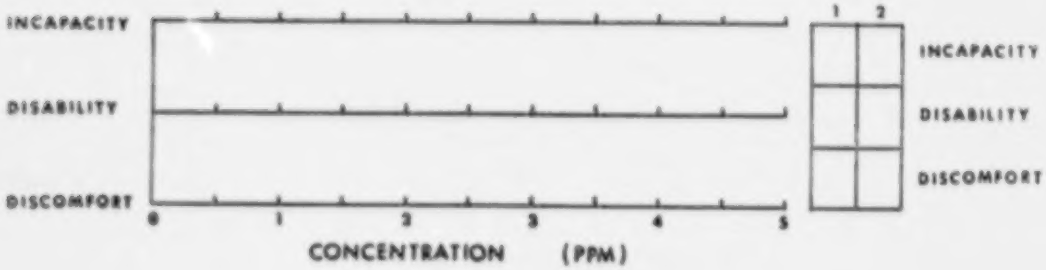


POLLUTANT: NITROGEN DIOXIDE

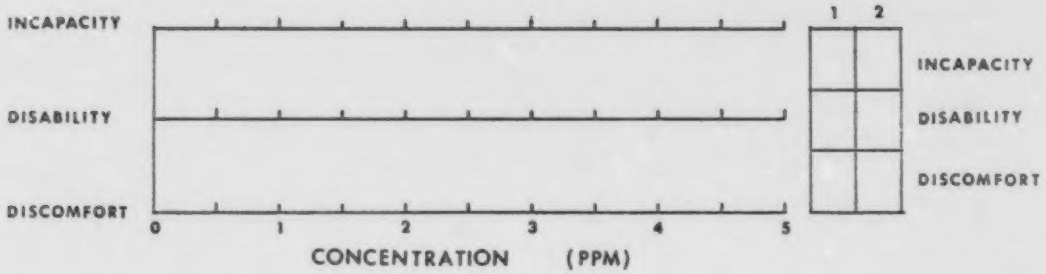
POPULATION CATEGORY:

ASTHMA

DEFINITION OF CONDITIONS:

- Incapacity = status asthmaticus
- Disability = asthmatic attack
- Discomfort = dyspnea

(1) 90%



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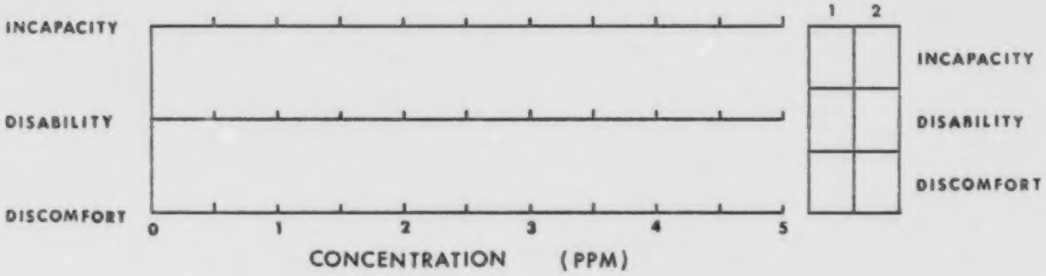

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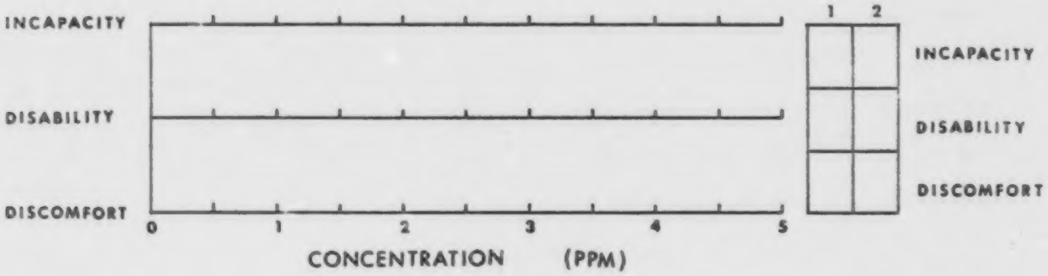

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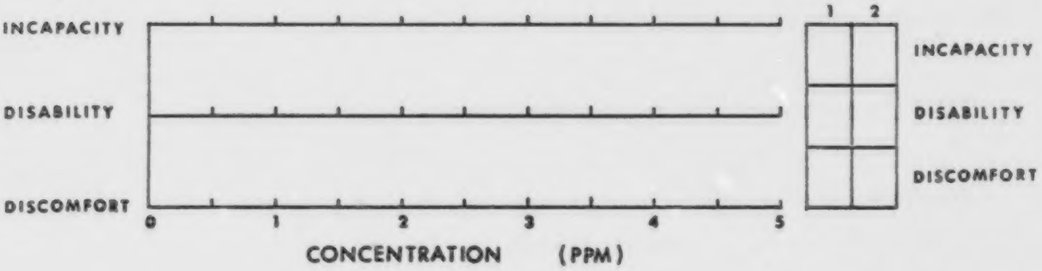

POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

ACUTE VIRIAL BRONCHITIS

DEFINITION OF CONDITIONS:

- Incapacity = acute respiratory failure
- Disability = dyspnea
- Discomfort = cough

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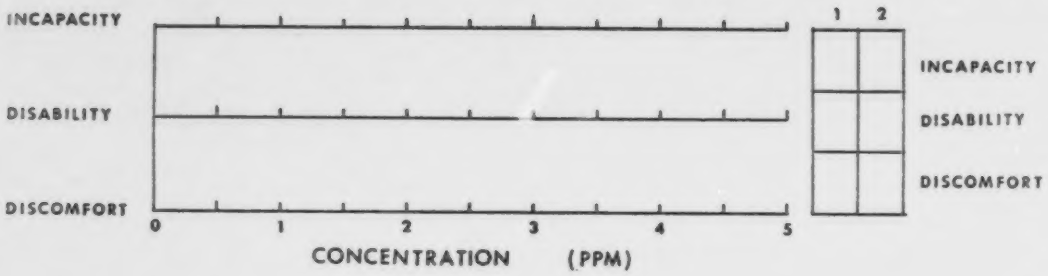

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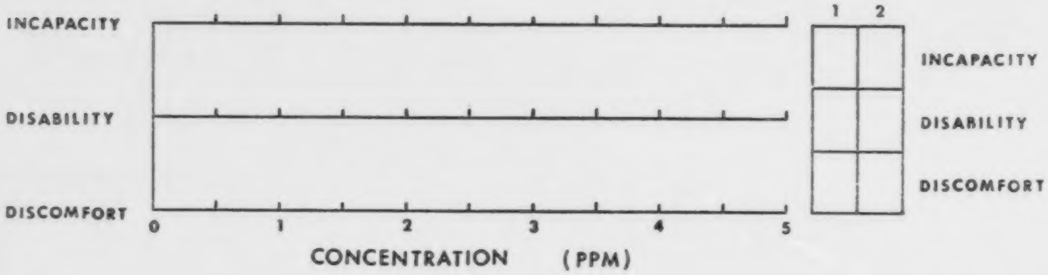

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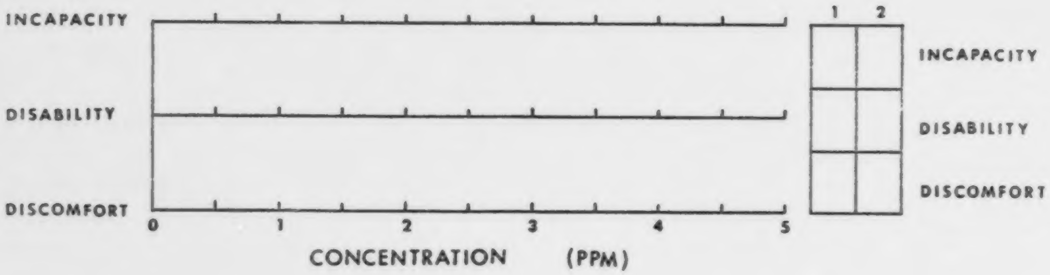

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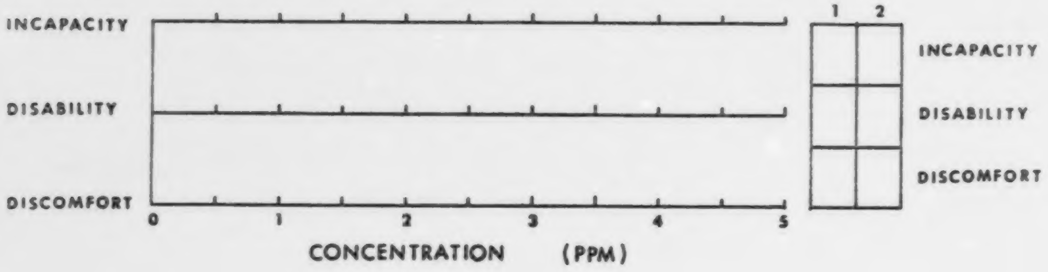


POLLUTANT: NITROGEN DIOXIDE

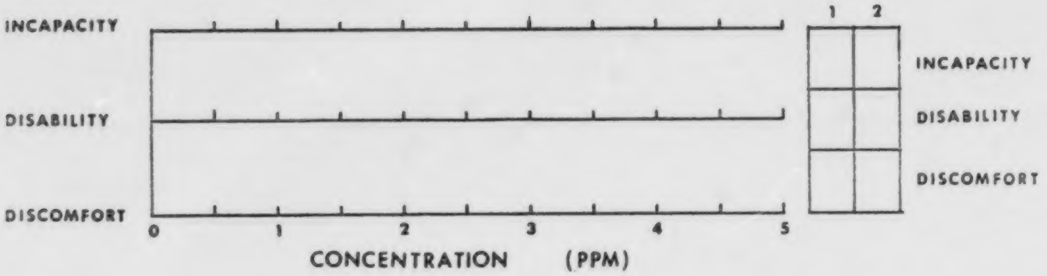
POPULATION CATEGORY:

ACUTE BACTERIAL PNEUMONIA

DEFINITION OF CONDITIONS:

- Incapacity = acute respiratory failure
- Disability = dyspnea
- Discomfort = cough

(1) 90%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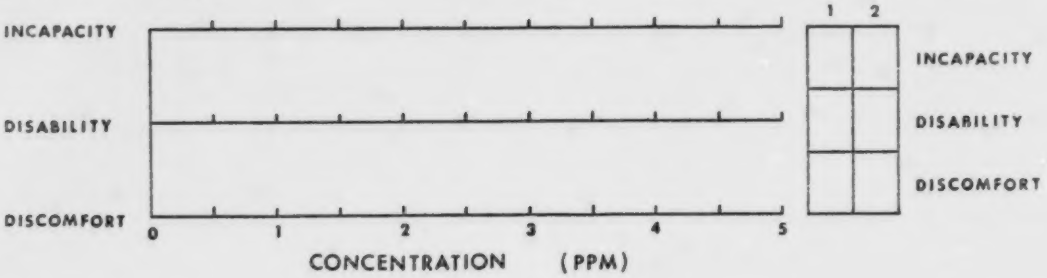
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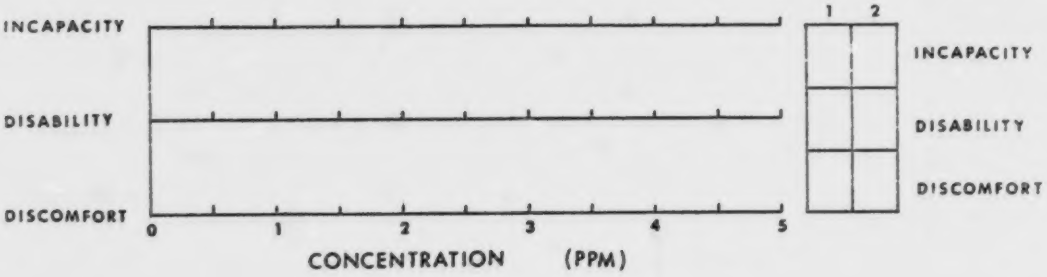
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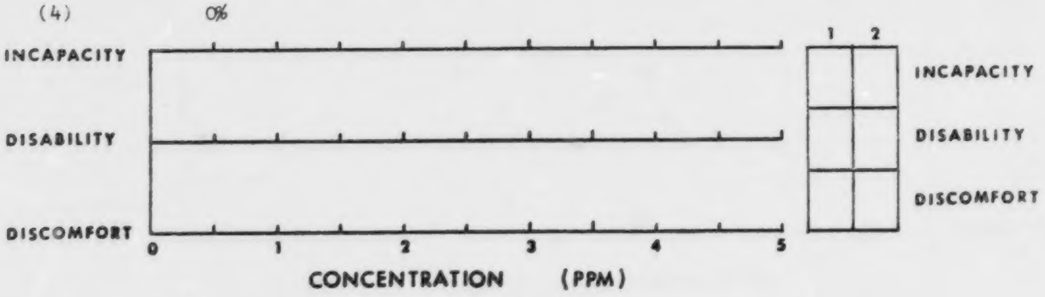
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POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

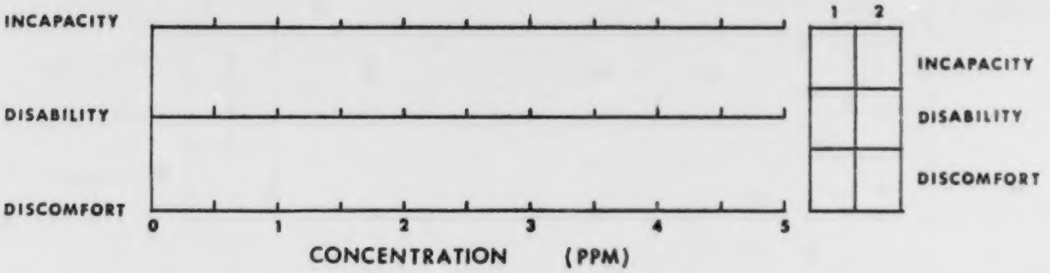
CHRONIC RESPIRATORY DISEASES**

** Chronic respiratory diseases of a non-infectious nature such as pneumoconiosis, or sarcoidodis.

DEFINITION OF CONDITIONS:

- Incapacity = pneumonia
- Disability = respiratory infection
- Discomfort = dyspnea

(1) 90%



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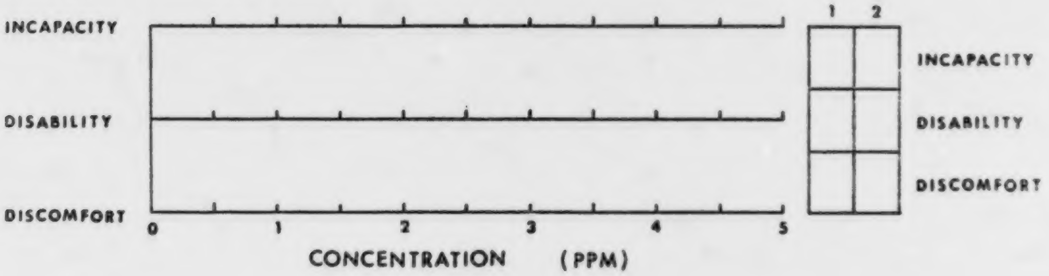

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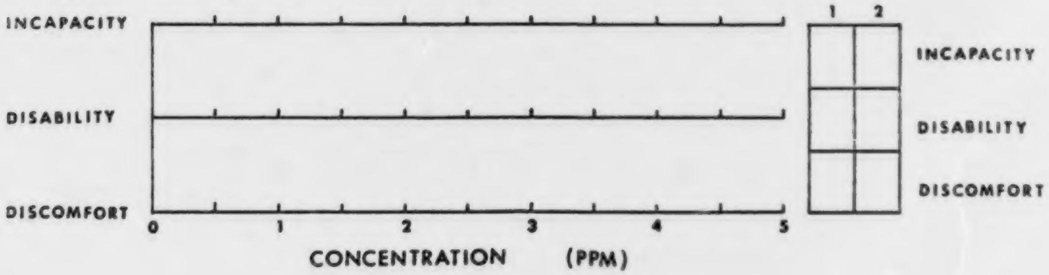

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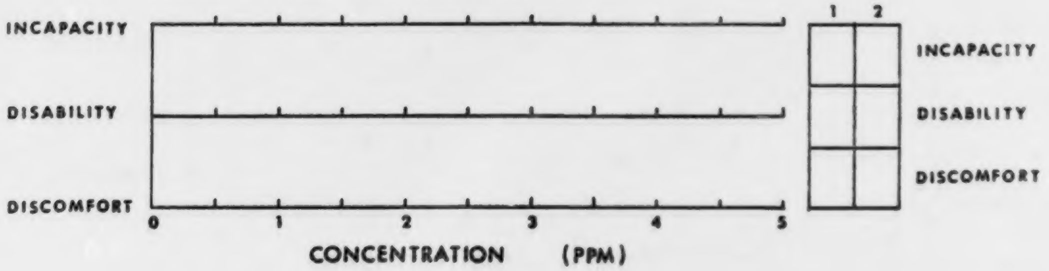


POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

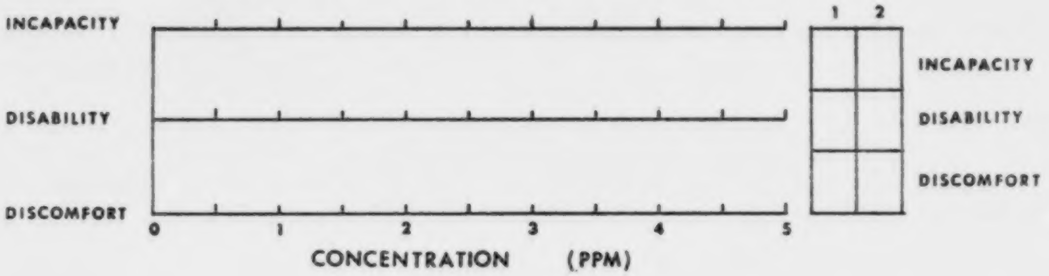
MILD CHRONIC OBSTRUCTIVE LUNG DISEASE**

** Patients with mild chronic obstructive pulmonary disease are defined as individuals who expectorates purulent sputum for periods of at least three months during each year.

DEFINITION OF CONDITIONS:

- Incapacity = broncho-pneumonia, cor pulmonale
- Disability = exacerbation of bronchitis, fever and increased sputum production and chest pain
- Discomfort = dyspnea

(1) 90%



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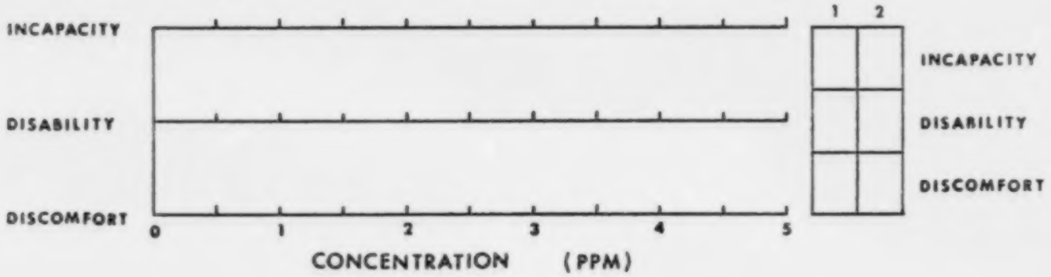

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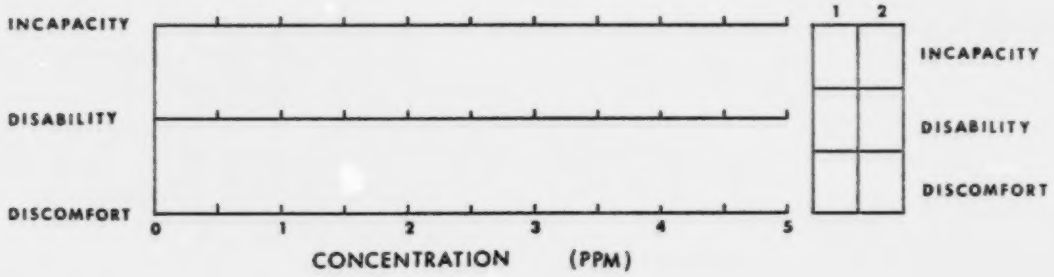

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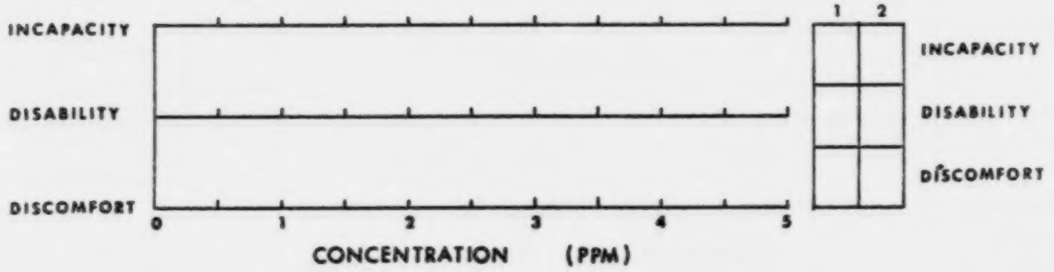


POLLUTANT: NITROGEN DIOXIDE

POPULATION CATEGORY:

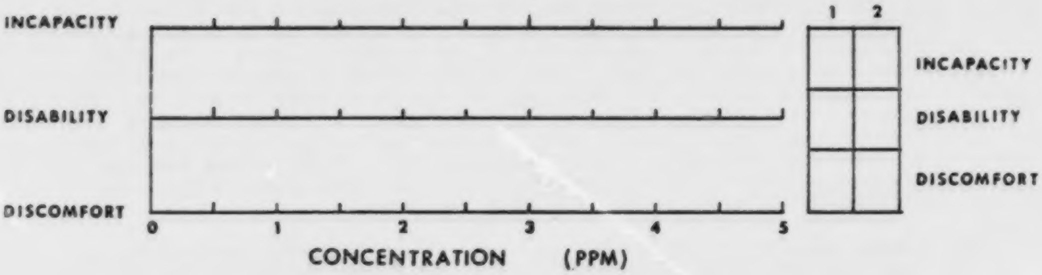
SEVERE CHRONIC OBSTRUCTIVE LUNG DISEASE**

** Patients with severe chronic obstructive pulmonary disease are defined as individuals who in addition to expectorating purulent sputum for periods of at least three months during each year, also, have a diminished FEV_1 and persistent hypoxemia with arterial blood oxygen tensions of $<$ 60 mm hg.

DEFINITION OF CONDITIONS:

- Incapacity = broncho-pneumonia, cor pulmonale
- Disability = exacerbation of bronchitis, fever and increased sputum production and chest pain
- Discomfort = dyspnea

(1) 90%



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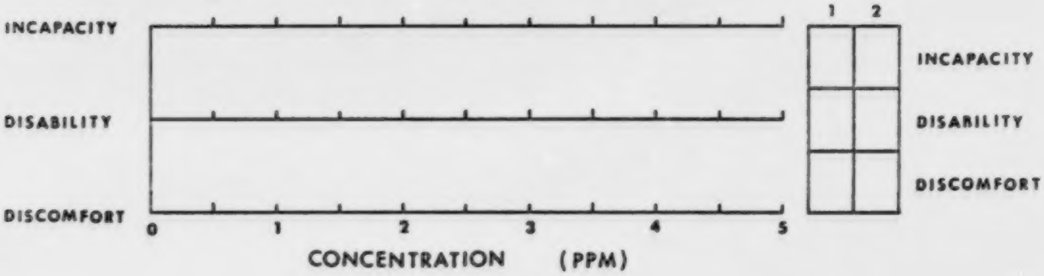

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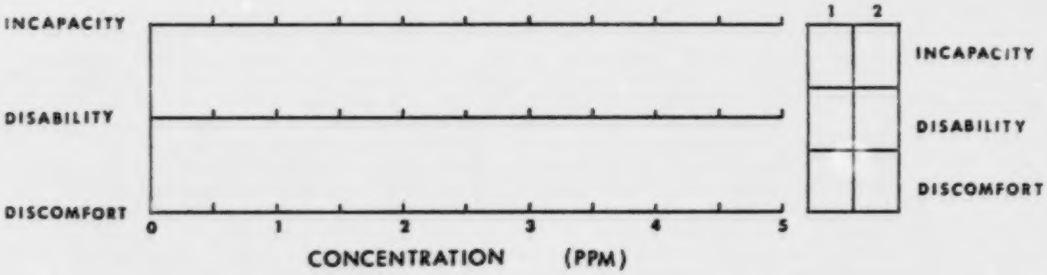

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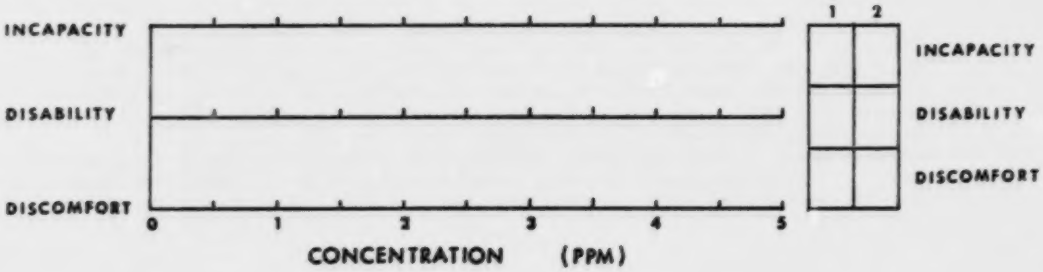


QUESTIONNAIRES FOR PROJECT

"HUMAN HEALTH DAMAGES FROM MOBILE SOURCE AIR POLLUTION"

CARBON MONOXIDE

The following questions apply to all population categories included in this study. Please use the attached sheets for your answers. The answers should be marked on the graphs and in boxes of appropriate column provided for each question.

(1) Please indicate by an X the pollutant concentrations which if present for one hour cause 90% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 90% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(2) Please indicate by an X the pollutant concentrations which if present for one hour cause 50% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 50% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(3) Please indicate by an X the pollutant concentrations which if present for one hour cause 10% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 10% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. In instances in which a health response occurs, write down the average duration of discomfort (hrs.), disability (hrs.), and incapacity (hrs.) in the boxes under Column (1) on the right. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc. If you believe that the response will occur at concentrations higher than those given in the scale, write these estimates in the space above the graphs.

(4) Please indicate by an X the pollutant concentrations which if present for one hour cause 0% of the stated population to suffer incapacity*, disability* and discomfort*. Indicate by a Y on both sides of your X, the range of pollution concentrations which will produce the indicated health responses for 0% of this population; by that we mean the lower limit Y_L, as the concentration at which you feel there is only a 5% chance the true answer would be below this estimate and the upper limit, Y_U, as the concentration at which you feel there is only a 5% chance the true answer would exceed your estimate. Indicate your degree of assurance concerning your answer in Column (2). Use a scale 1-10 where 10 means "I know the answer very well" and 1 means, "my answer is a sheer guess". Considerations to take into account in making this judgment are, how good is the information concerning this item; how well can it be estimated, etc.

POLLUTANT: CARBON MONOXIDE

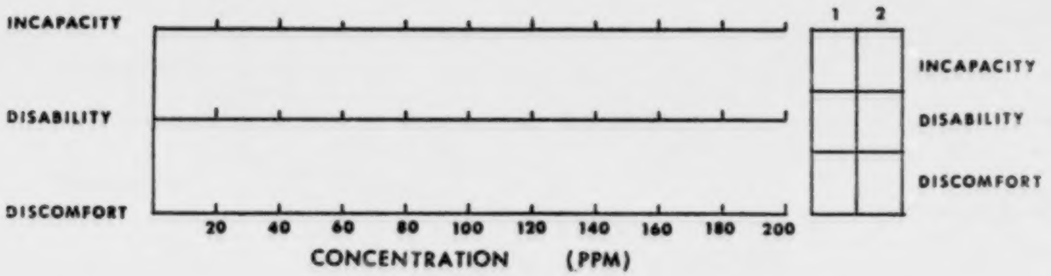
POPULATION CATEGORY:

NORMAL

DEFINITION OF CONDITIONS:

- Incapacity = coma or convulsions
- Disability = throbbing headache, confusion, irritabilit dizziness
- Discomfort = mild headache, errors in cognitive functio

(1) 90%



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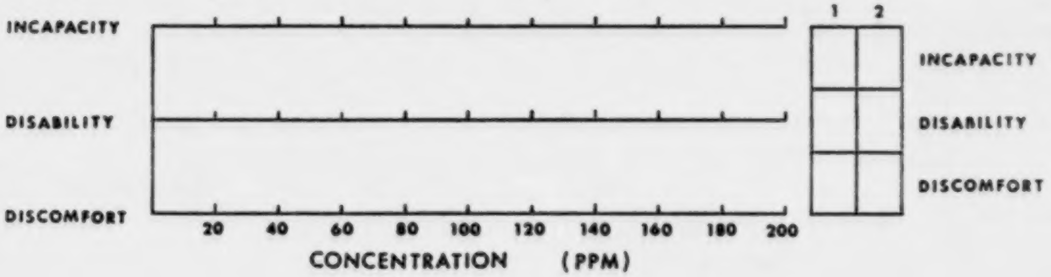

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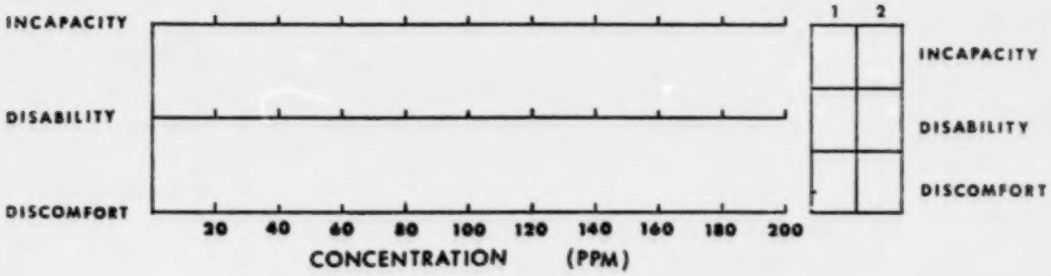

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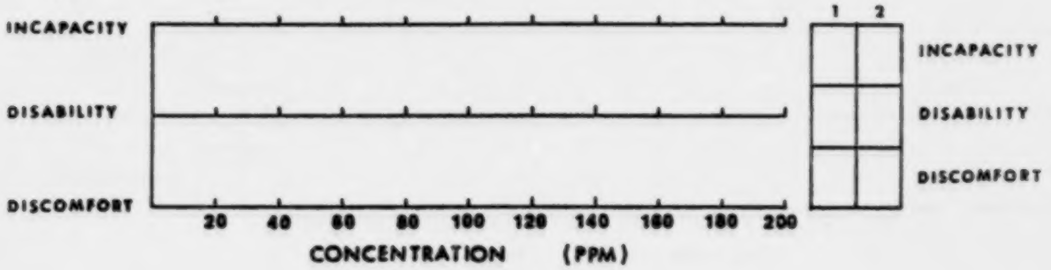


POLLUTANT: CARBON MONOXIDE

POPULATION CATEGORY:

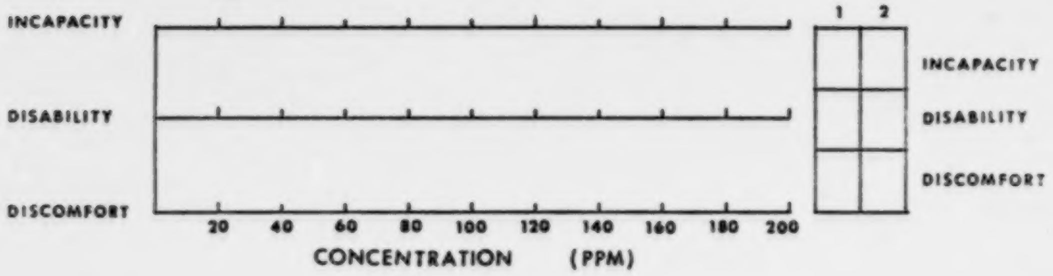
CHILDREN**

** Children - healthy children of less than 10 years of age.

DEFINITION OF CONDITIONS:

- Incapacity = coma or convulsions
- Disability = throbbing headache, confusion, irritability, dizziness
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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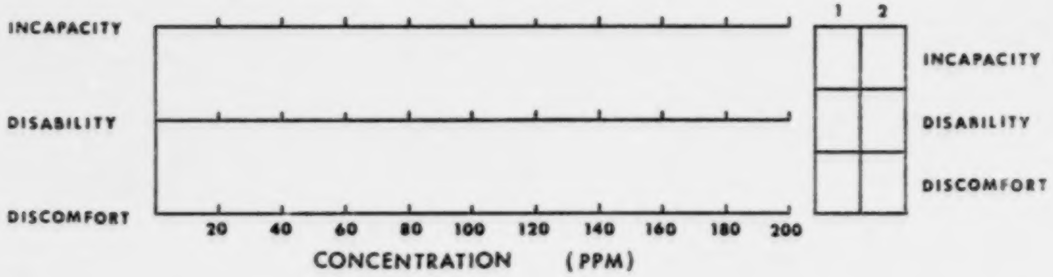

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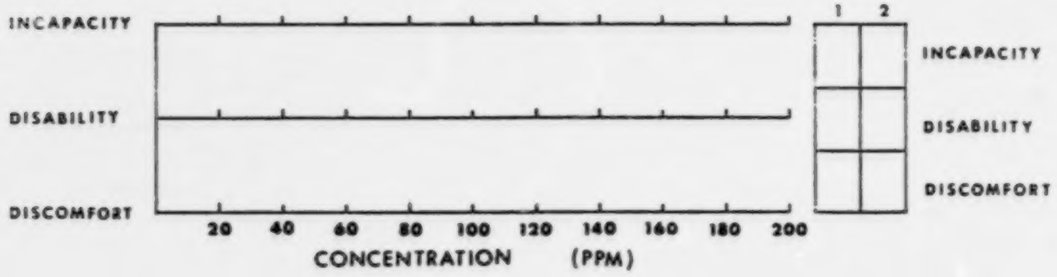

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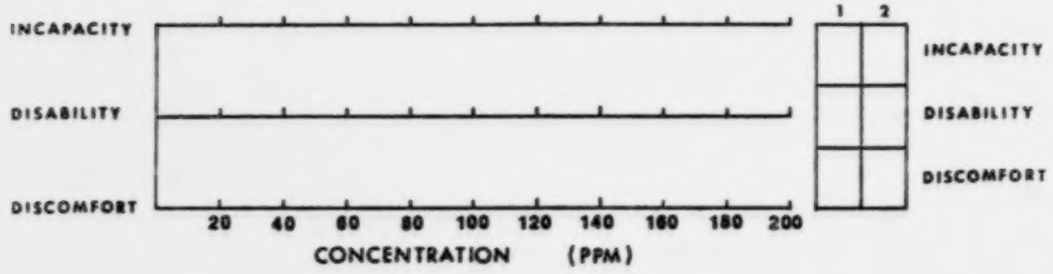


POLLUTANT: CARBON MONOXIDE

POPULATION CATEGORY:

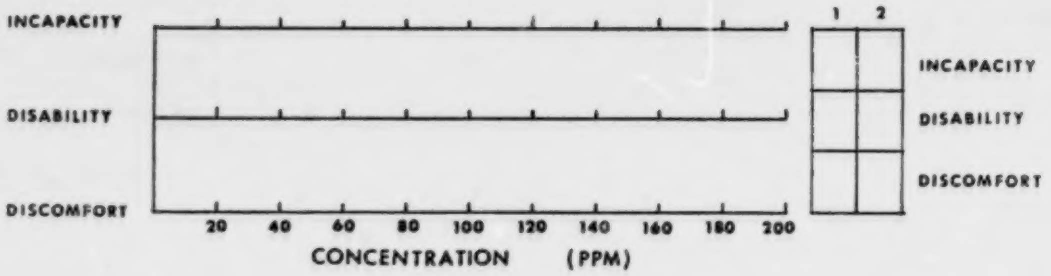
OLD AGE**

** Old Age - patients who have no proven underlining disease but who on an epidemiologic basis are likely to have senile emphysema and arteriosclerotic cardiovascular disease (ASCVD).

DEFINITION OF CONDITIONS:

- Incapacity = coma or convulsions
- Disability = throbbing headache, confusion, irritabilit, dizziness
- Discomfort = mild headache, errors in cognitive function

(1) 90%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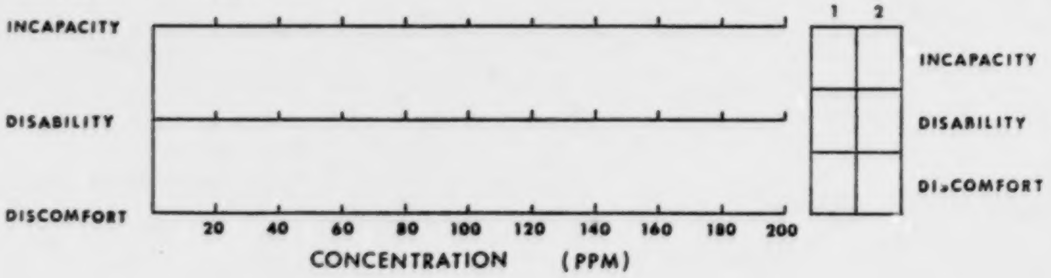
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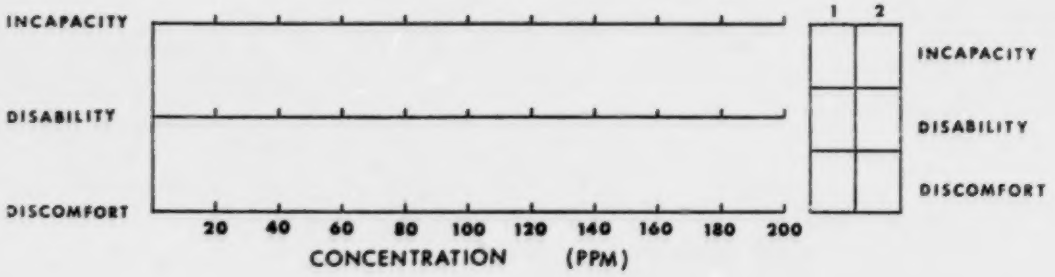
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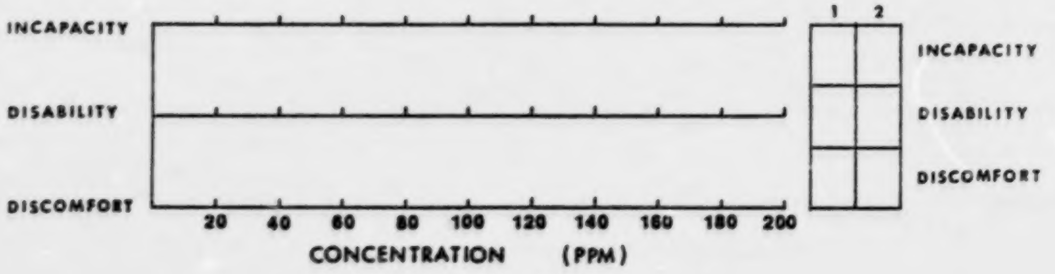
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POLLUTANT: CARBON MONOXIDE

POPULATION CATEGORY:

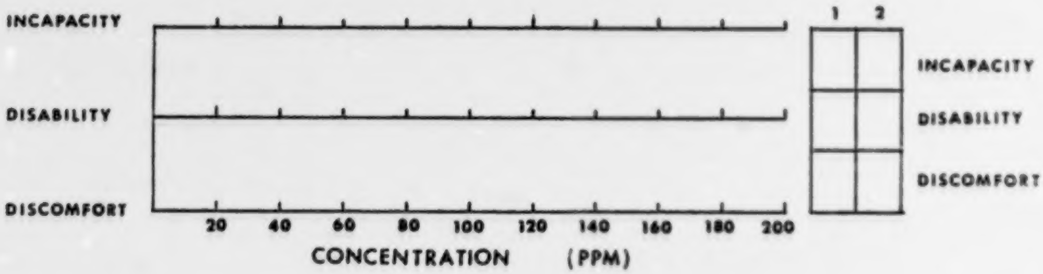
HEART CONDITION, MILD**

** Heart condition due to any etiology such as arteriosclerotic cardiovascular disease (ASCVD), rheumatic heart disease, hypertension, ASCVD without evidence of congestive heart failure.

DEFINITION OF CONDITIONS:

- Incapacity = angina pectoris, arrythmia, coma or convulsions
- Disability = throbbing headache, confusion, irritability, dizziness, and increase in dyspnea
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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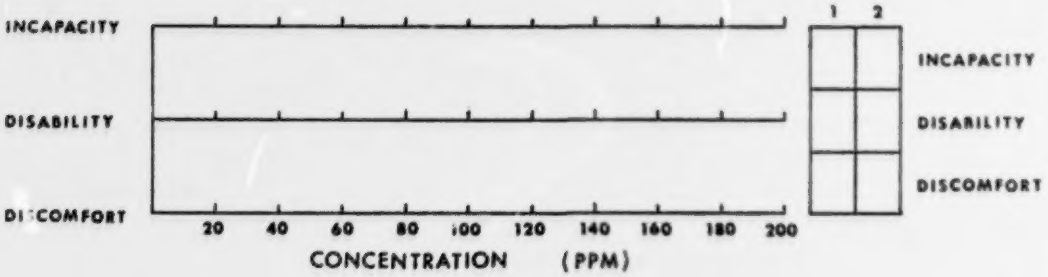

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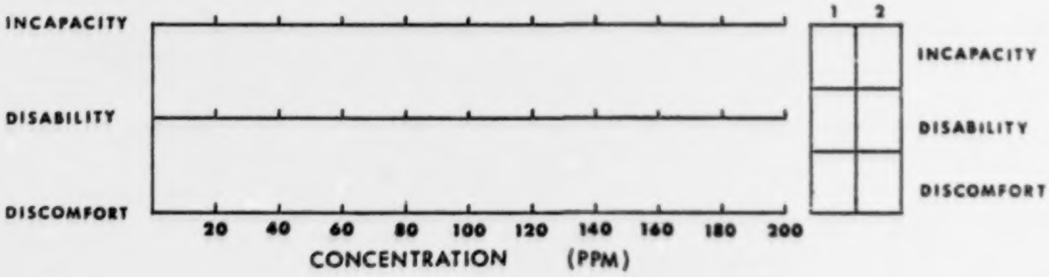

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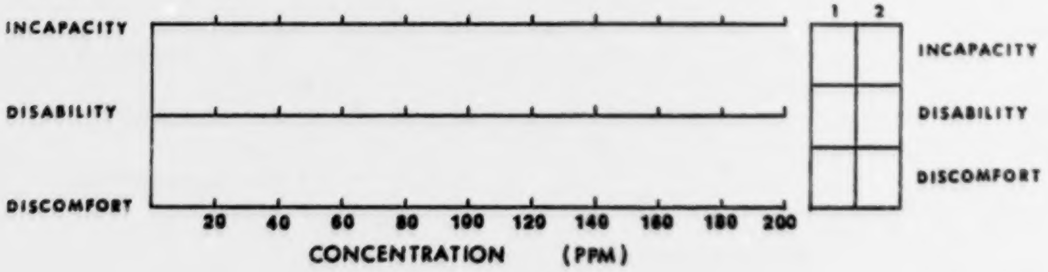


POLLUTANT: CARBON MONOXIDE

POPULATION CATEGORY:

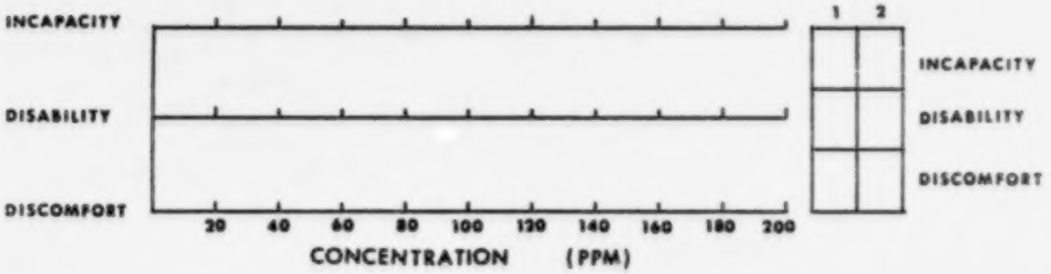
HEART CONDITION, SEVERE**

** Heart condition due to any etiology such as arteriosclerotic cardiovascular disease (ASCVD), hypertension, rheumatic heart disease with clinical evidence of heart failure.

DEFINITION OF CONDITIONS:

- Incapacity = congestive heart failure
- Disability = congestive heart failure
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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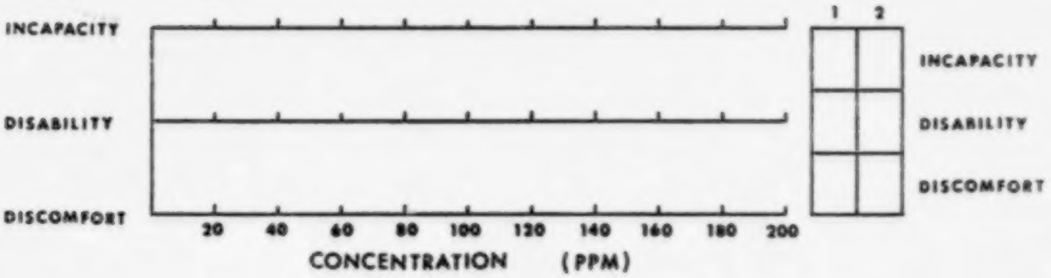

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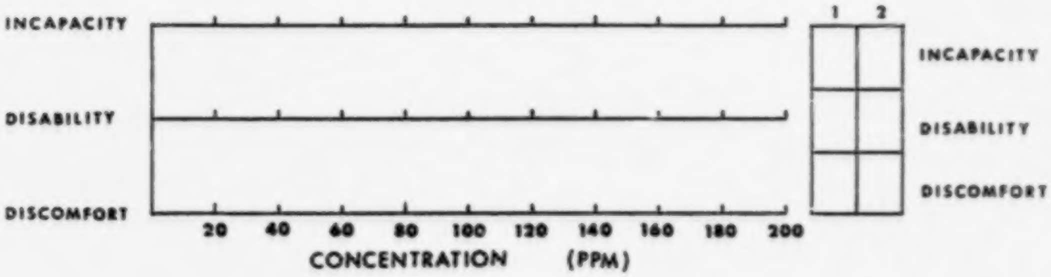

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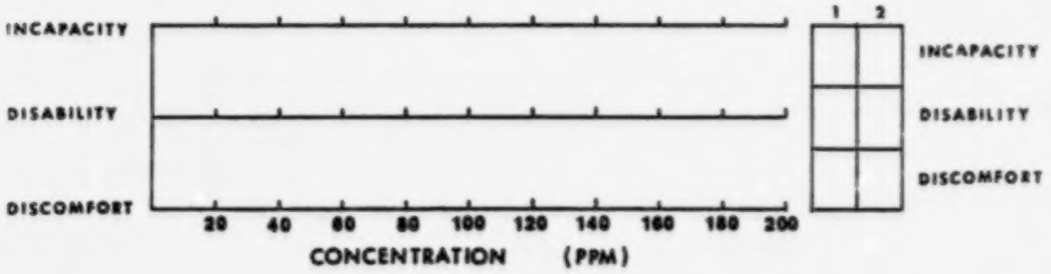


POLLUTANT: CARBON MONOXIDE

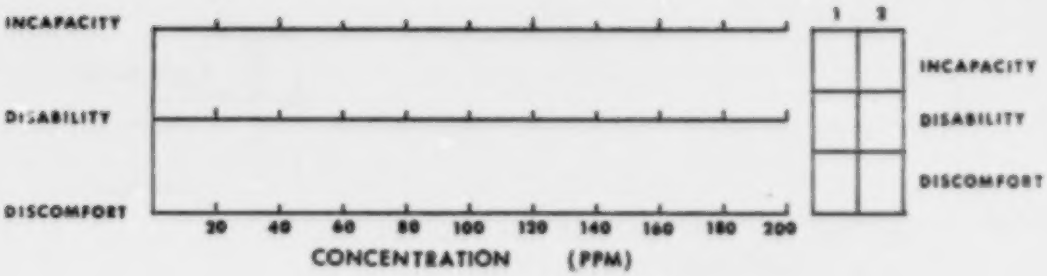
POPULATION CATEGORY:

HAY FEVER, SINUSITIS

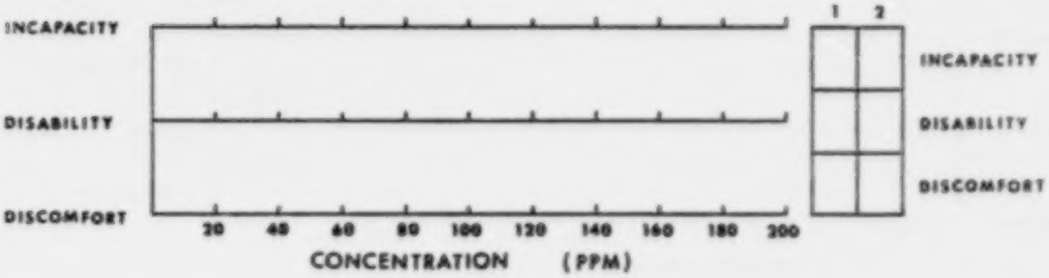
DEFINITION OF CONDITIONS:

- Incapacity = coma or convulsions
- Disability = throbbing headache, confusion, irritability dizziness
- Discomfort = mild headache, errors in cognitive function

(1) 90%


INCAPACITY
DISABILITY
DISCOMFORT
20
40
60
80
100
120
140
160
180
200
CONCENTRATION (PPM)
1
2
INCAPACITY
DISABILITY
DISCOMFORT

(2) 50%


INCAPACITY
DISABILITY
DISCOMFORT
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CONCENTRATION (PPM)
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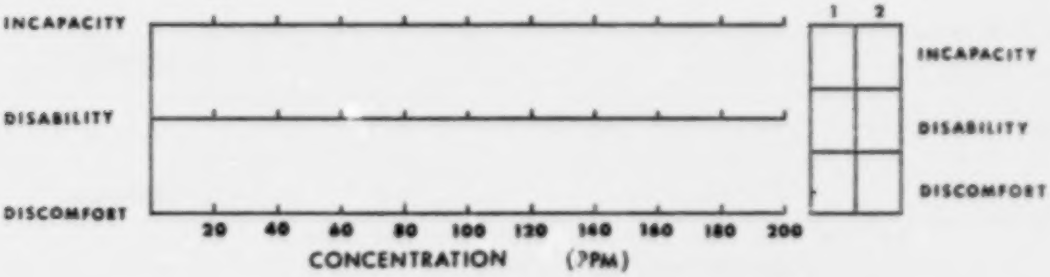
INCAPACITY
DISABILITY
DISCOMFORT

(3) 10%


INCAPACITY
DISABILITY
DISCOMFORT
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CONCENTRATION (PPM)
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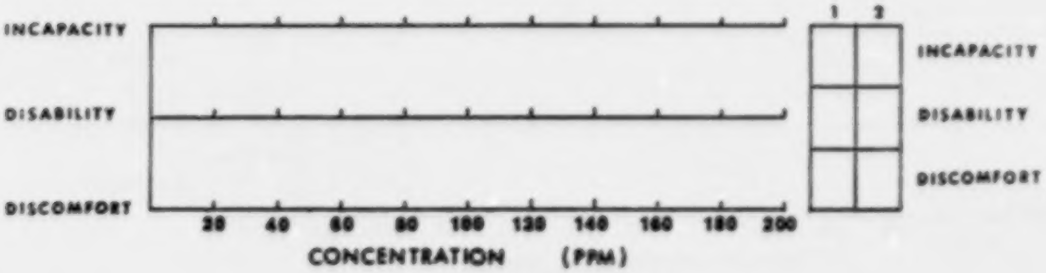
2
INCAPACITY
DISABILITY
DISCOMFORT

(4) 0%


INCAPACITY
DISABILITY
DISCOMFORT
20
40
60
80
100
120
140
160
180
200
CONCENTRATION (PPM)
1
2
INCAPACITY
DISABILITY
DISCOMFORT

POLLUTANT: CARBON MONOXIDE

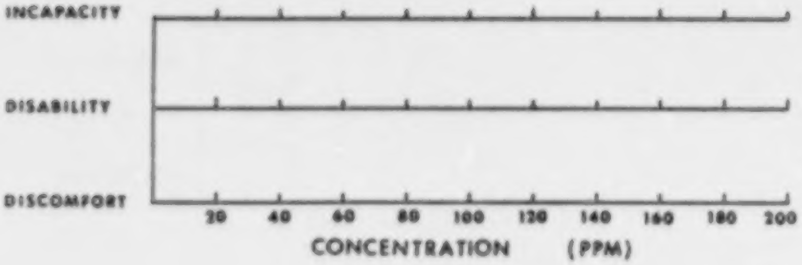
POPULATION CATEGORY:

INFLUENZA

DEFINITION OF CONDITIONS:

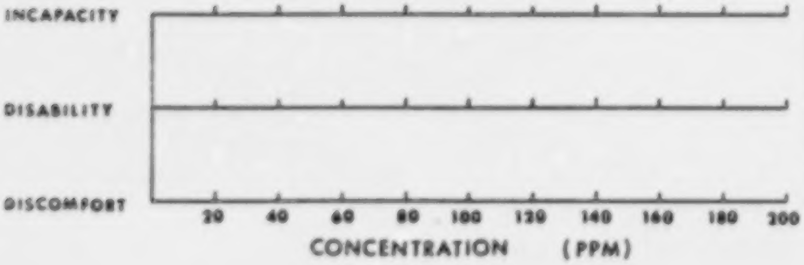
- Incapacity = respiratory failure, coma, convulsions
- Disability = throbbing headache, confusion, irritability, dizziness, increase in dyspnea
- Discomfort = mild headache, errors in cognitive function

(1) 90%



	1	2
INCAPACITY		
DISABILITY		
DISCOMFORT		

(2) 50%



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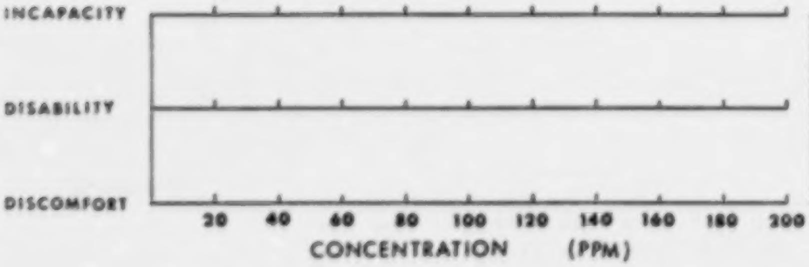
INCAPACITY		
DISABILITY		
DISCOMFORT		

(3) 10%



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INCAPACITY		
DISABILITY		
DISCOMFORT		

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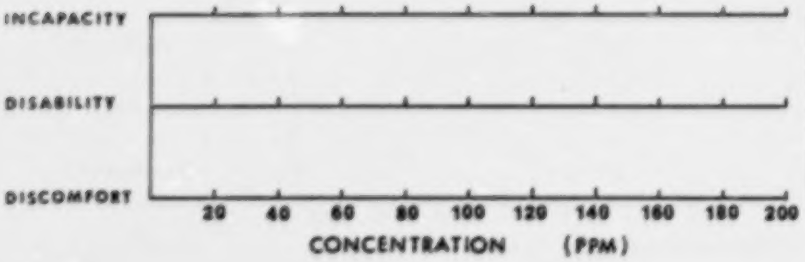


	1	2
INCAPACITY		
DISABILITY		
DISCOMFORT		

POLLUTANT: CARBON MONOXIDE

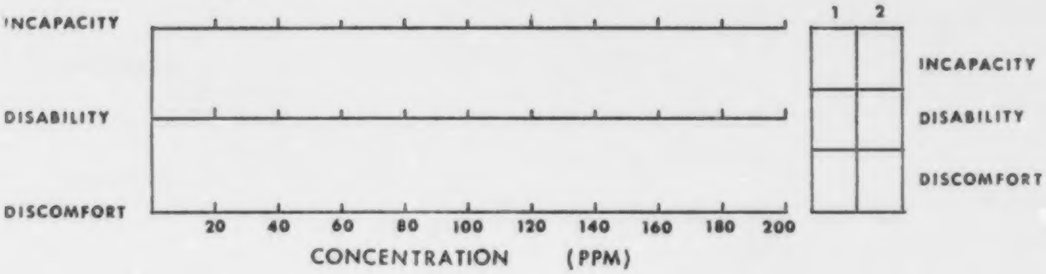
POPULATION CATEGORY:

UPPER RESPIRATORY INFECTION

DEFINITION OF CONDITIONS:

- Incapacity = coma or convulsions
- Disability = throbbing headache, confusion, irritability, dizziness
- Discomfort = mild headache, errors in cognitive function

(1) 90%


INCAPACITY
DISABILITY
DISCOMFORT
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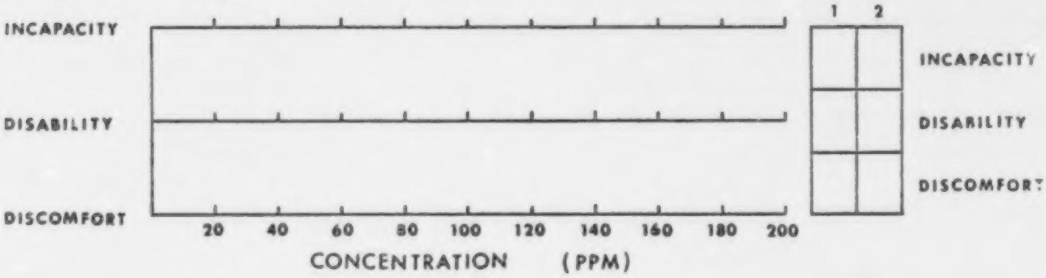
CONCENTRATION (PPM)
1
2
INCAPACITY
DISABILITY
DISCOMFORT

(2) 50%


INCAPACITY
DISABILITY
DISCOMFORT
20
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CONCENTRATION (PPM)
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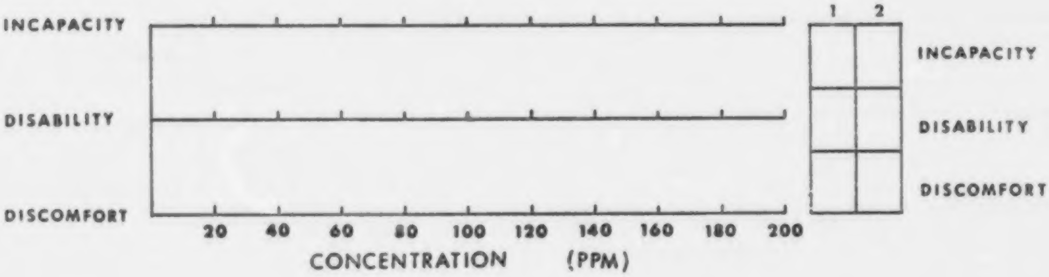
INCAPACITY
DISABILITY
DISCOMFORT

(3) 10%


INCAPACITY
DISABILITY
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CONCENTRATION (PPM)
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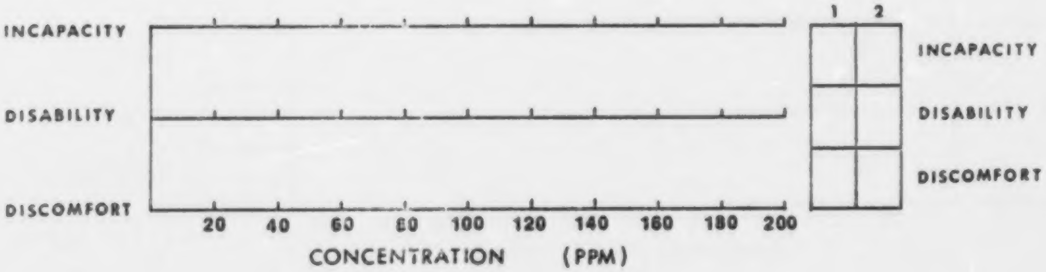
2
INCAPACITY
DISABILITY
DISCOMFORT

(4) 0%


INCAPACITY
DISABILITY
DISCOMFORT
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80
100
120
140
160
180
200
CONCENTRATION (PPM)
1
2
INCAPACITY
DISABILITY
DISCOMFORT

POLLUTANT: CARBON MONOXIDE

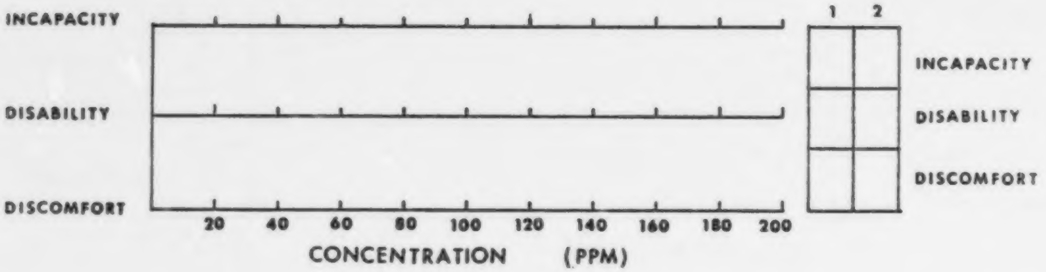
POPULATION CATEGORY:

ASTHMA

DEFINITION OF CONDITIONS:

- Incapacity = coma or convulsions
- Disability = throbbing headache, confusion, irritability, dizziness
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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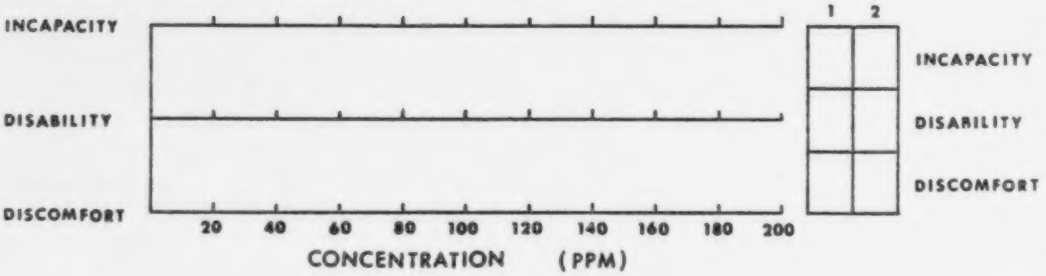

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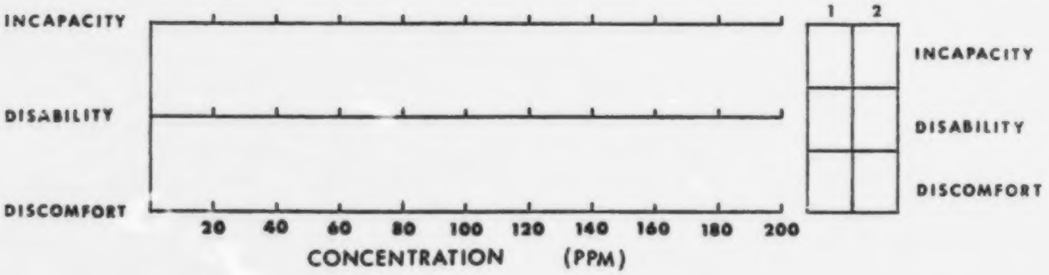

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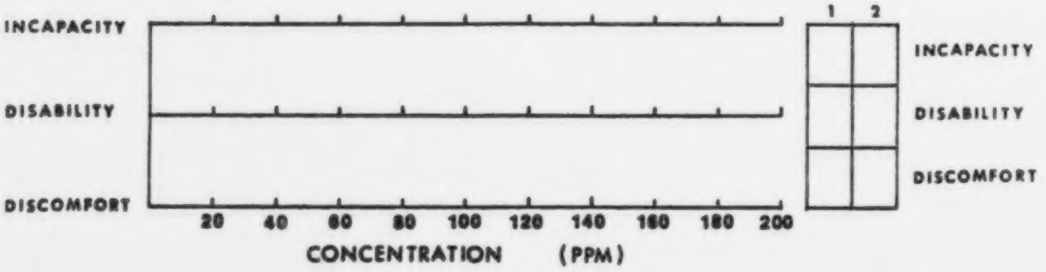


POLLUTANT: CARBON MONOXIDE

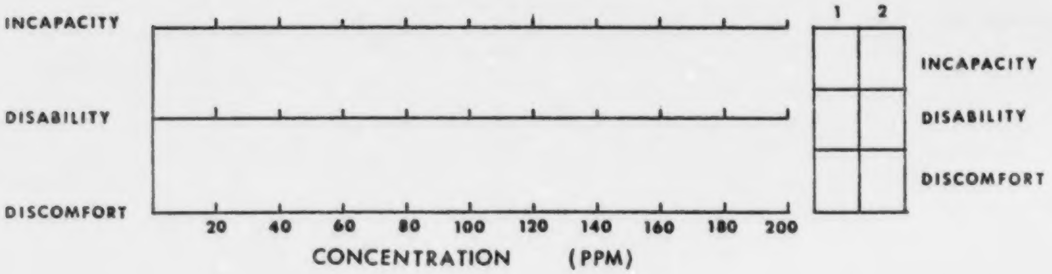
POPULATION CATEGORY:

ACUTE VIRIAL BRONCHITIS

DEFINITION OF CONDITIONS:

- Incapacity = without respiratory failure, coma, convulsions
- Disability = throbbing headache, confusion, irritabilit dizziness, increase in dyspnea
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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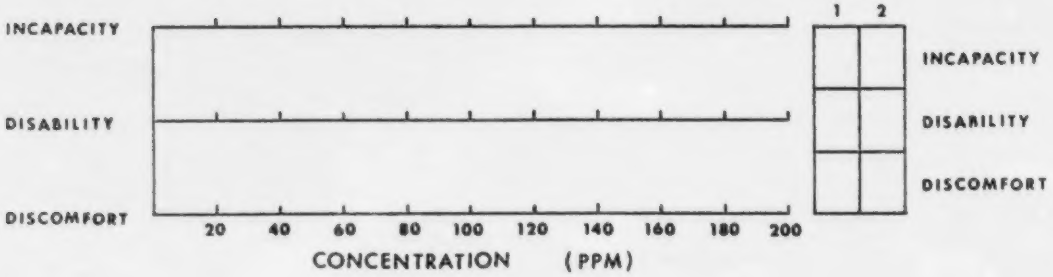

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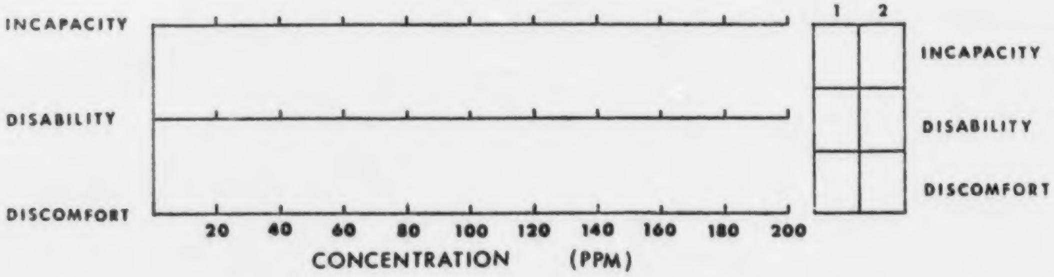

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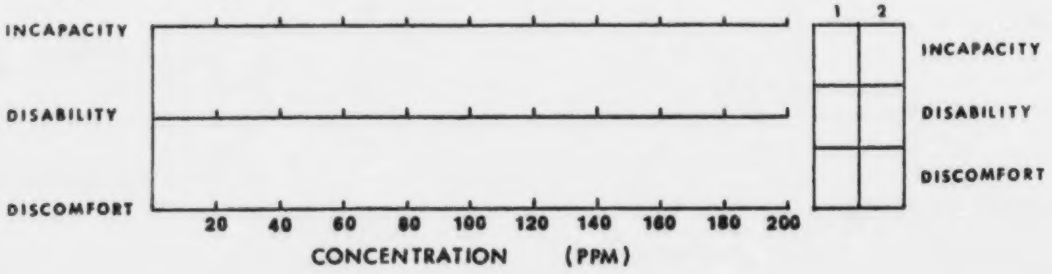


POLLUTANT: CARBON MONOXIDE

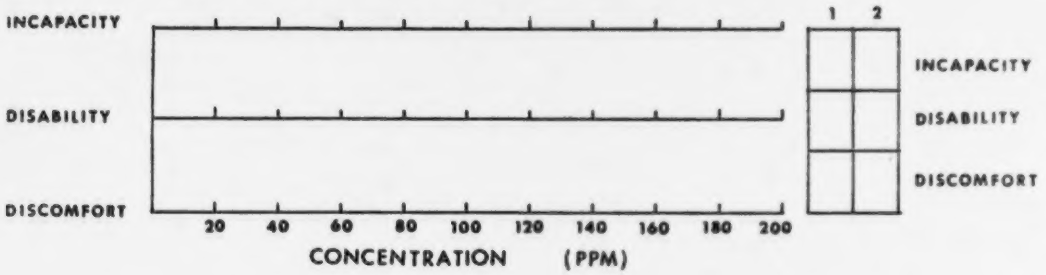
POPULATION CATEGORY:

ACUTE BACTERIAL PNEUMONIA

DEFINITION OF CONDITIONS:

- Incapacity = respiratory failure, coma, convulsions
- Disability = throbbing headache, confusion, irritability dizziness, increase in dyspnea
- Discomfort = mild headache, errors in congnitive function

(1) 90%



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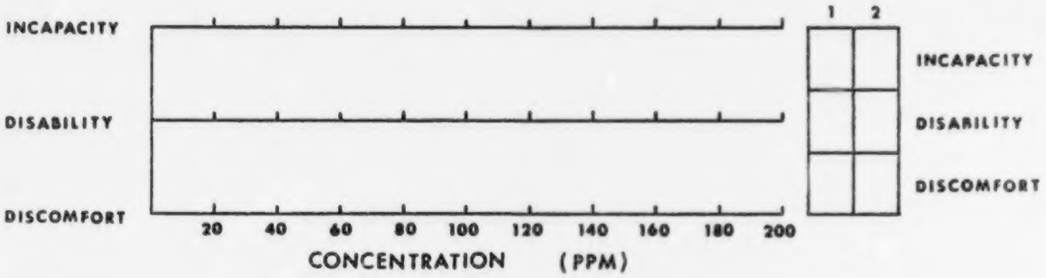

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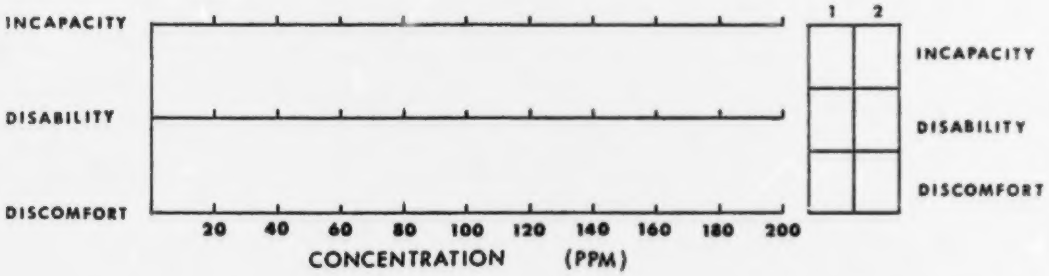

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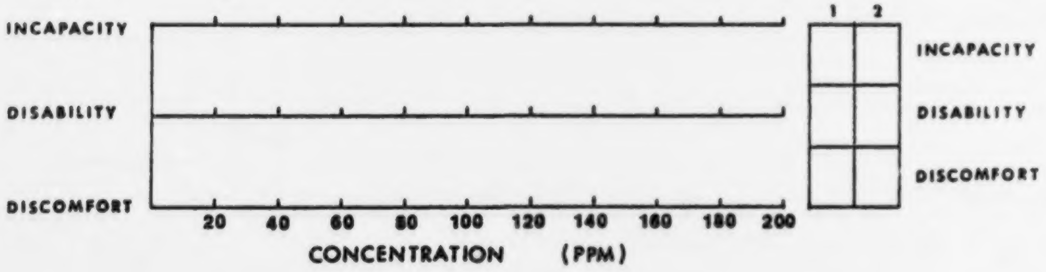


POLLUTANT: CARBON MONOXIDE

POPULATION CATEGORY:

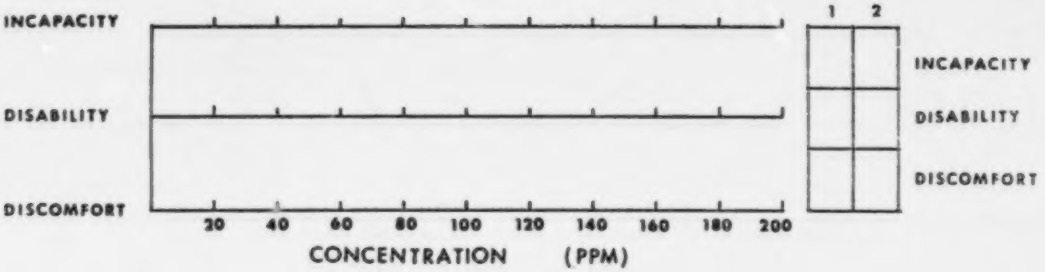
CHRONIC RESPIRATORY DISEASES**

** Chronic respiratory diseases of a non-infectious nature such as pneumoconiosis, or sarcoidosis.

DEFINITION OF CONDITIONS:

- Incapacity = respiratory failure, coma, convulsions
- Disability = throbbing headache, confusion, irritability, dizziness, and increase in dyspnea
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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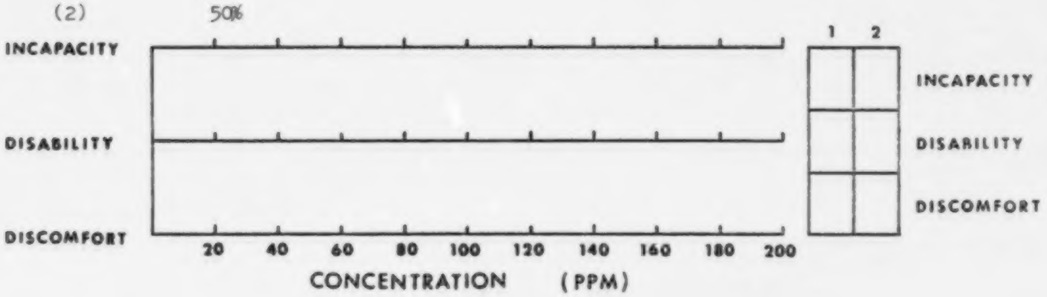

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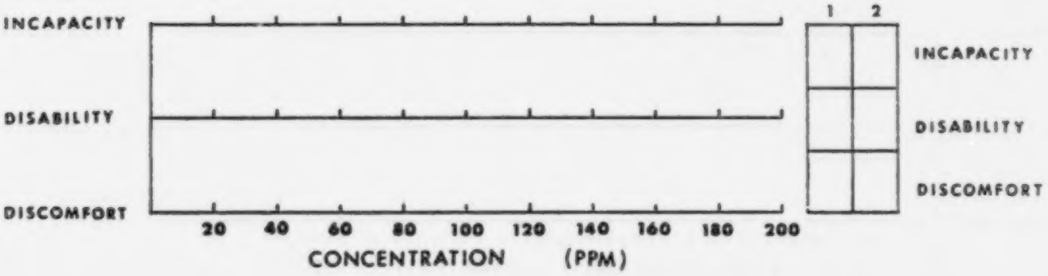

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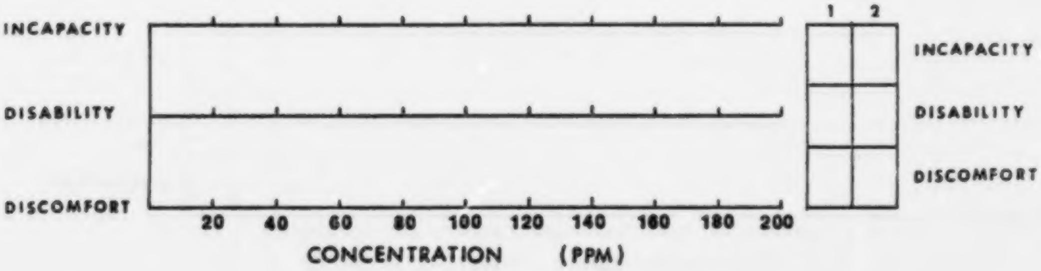


POLLUTANT: CARBON MONOXIDE

POPULATION CATEGORY:

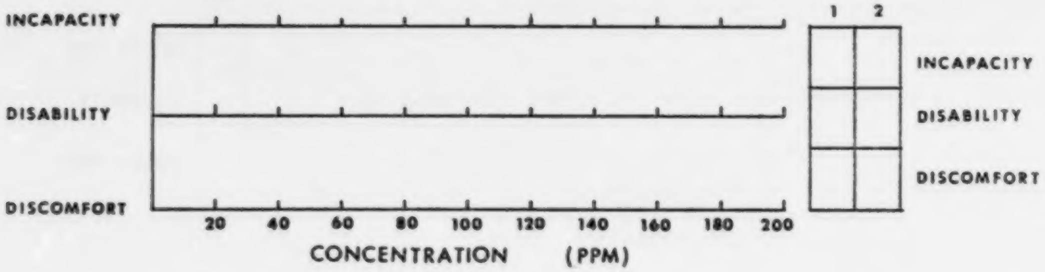
MILD CHRONIC OBSTRUCTIVE PULMONARY DISEASE**

** Patients with mild chronic obstructive pulmonary disease are defined as individuals who expectorates purulent sputum for periods of at least three months during each year.

DEFINITION OF CONDITIONS:

- Incapacity = coma or convulsions
- Disability = throbbing headache, confusion, irritability, dizziness
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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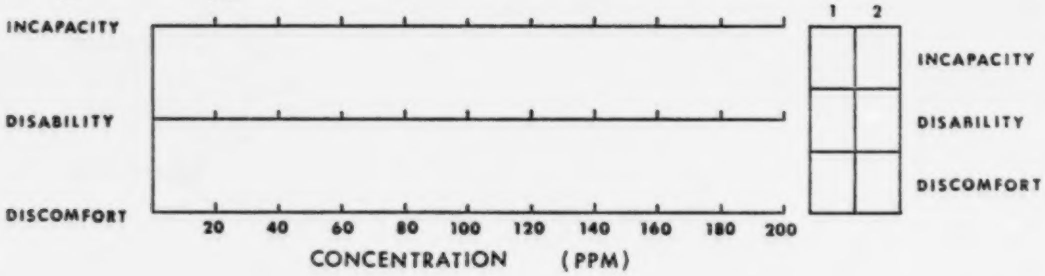

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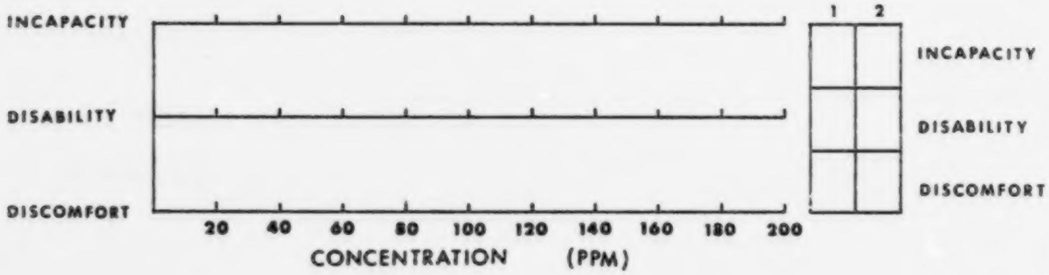

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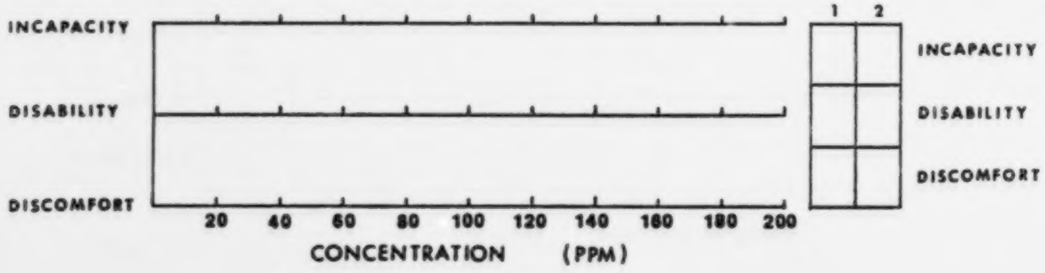


POLLUTANT: CARBON MONOXIDE

POPULATION CATEGORY:

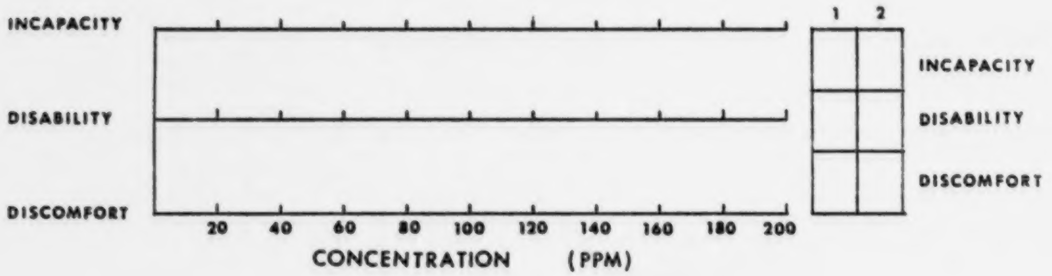
SEVERE CHRONIC OBSTRUCTIVE PULMONARY DISEASE**

** Patients with severe chronic obstructive pulmonary disease are defined as individuals who in addition to expectorating purulent sputum for periods of at least three months during each year, also, have a diminished FEV_1 and persistent hypoxemia with arterial blood oxygen tensions of $<$ 60 mm hg.

DEFINITION OF CONDITIONS:

- Incapacity = respiratory failure, coma, convulsions
- Disability = throbbing headache, confusion, irritability, dizziness, and increase in dyspnea
- Discomfort = mild headache, errors in cognitive function

(1) 90%



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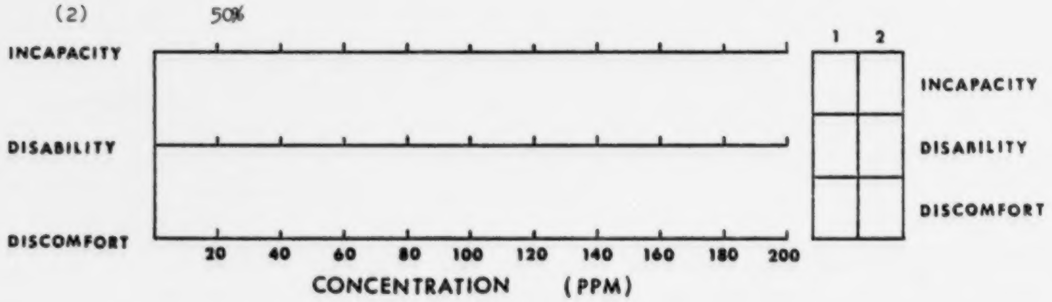

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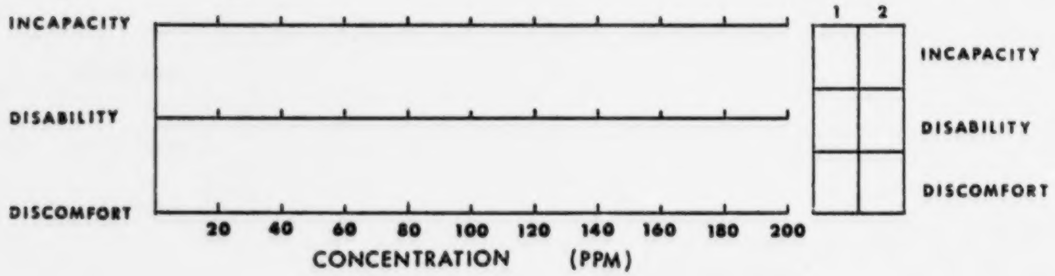

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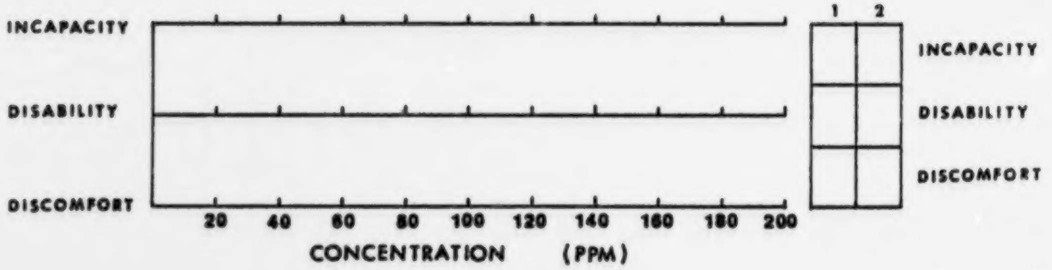

APPENDIX B

SECOND ROUND SURVEY DOSE-RESPONSE CURVES

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Graph

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M. Mild Chronic Obstructive Lung Disease 79-81
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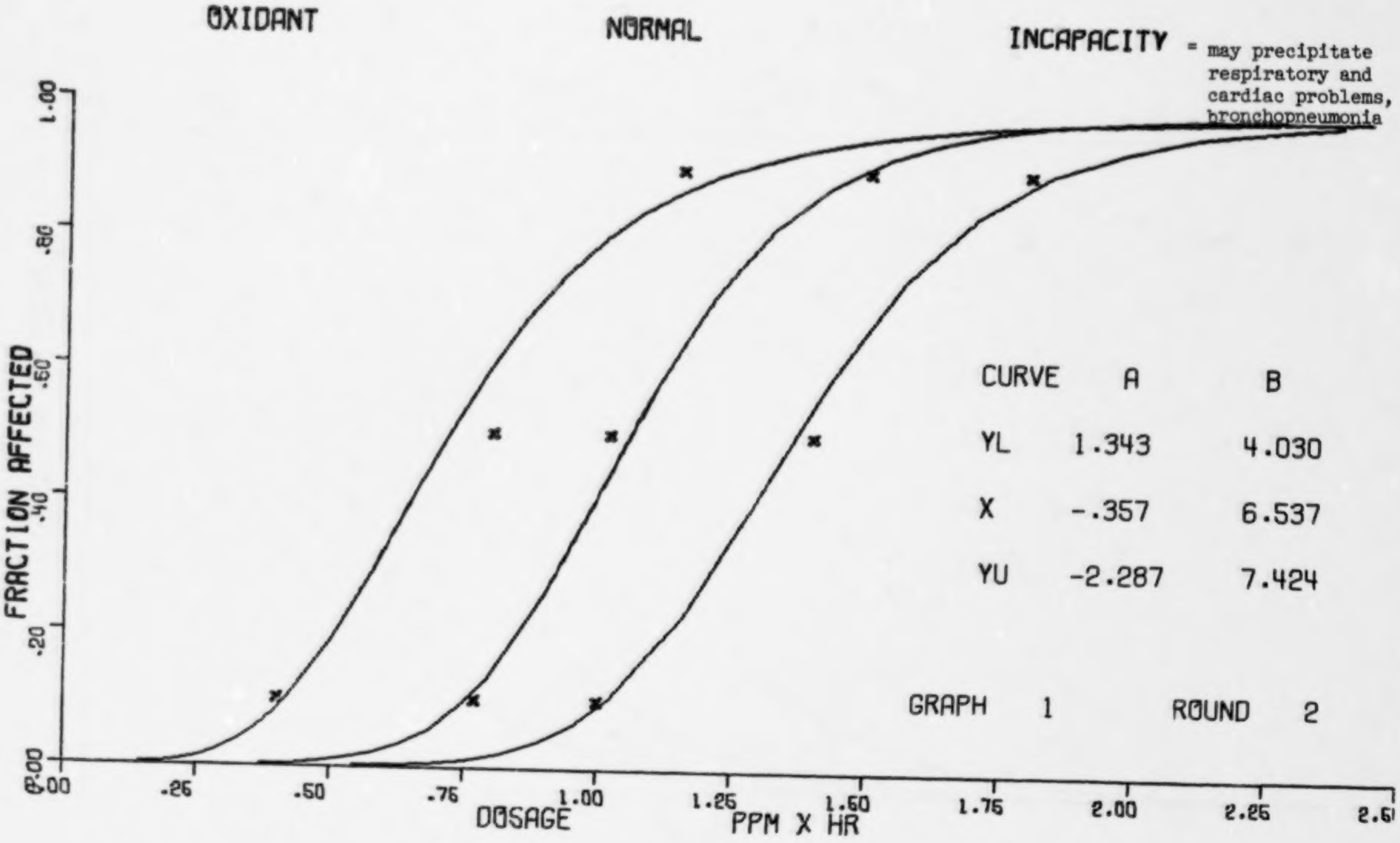
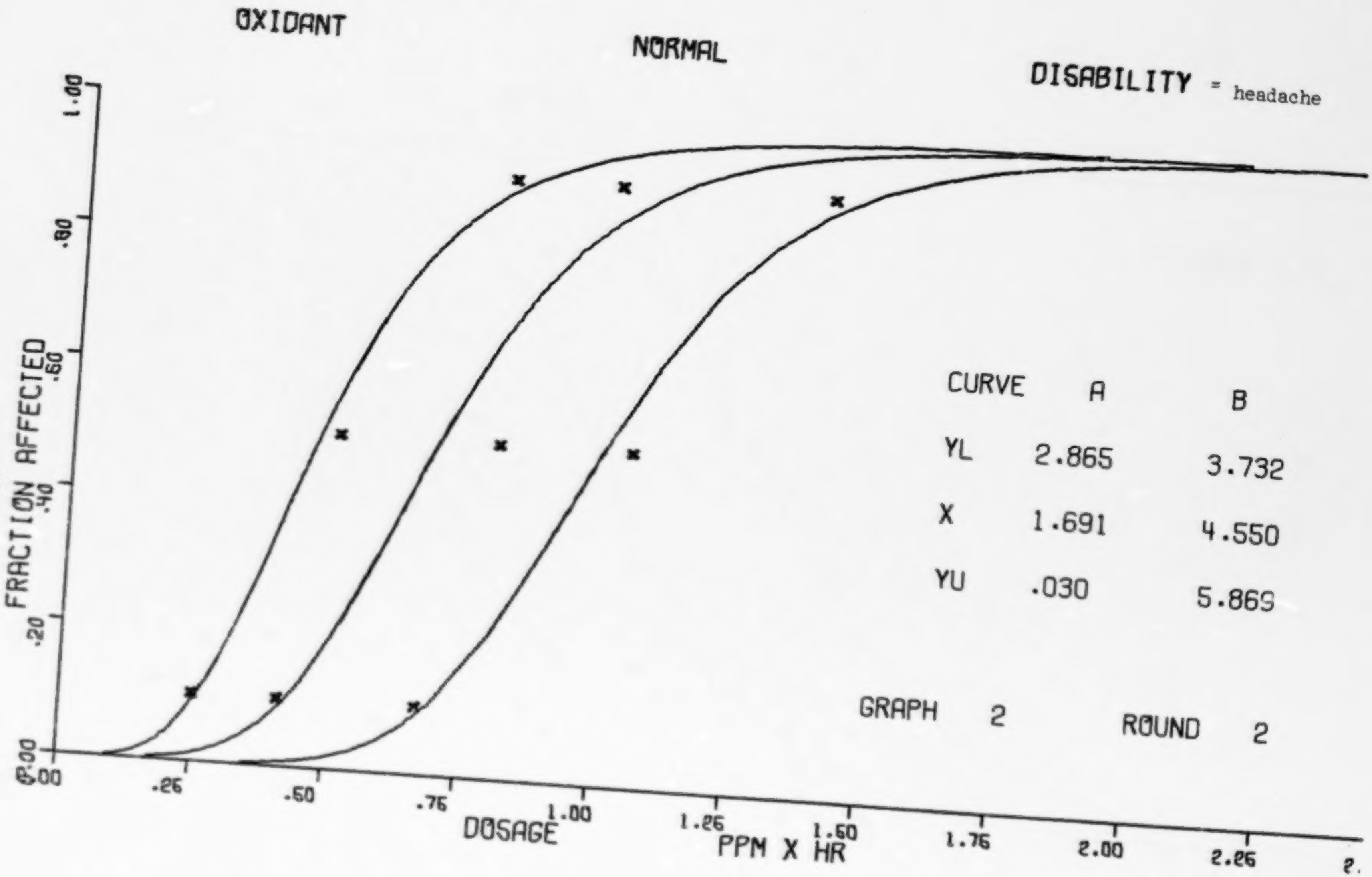
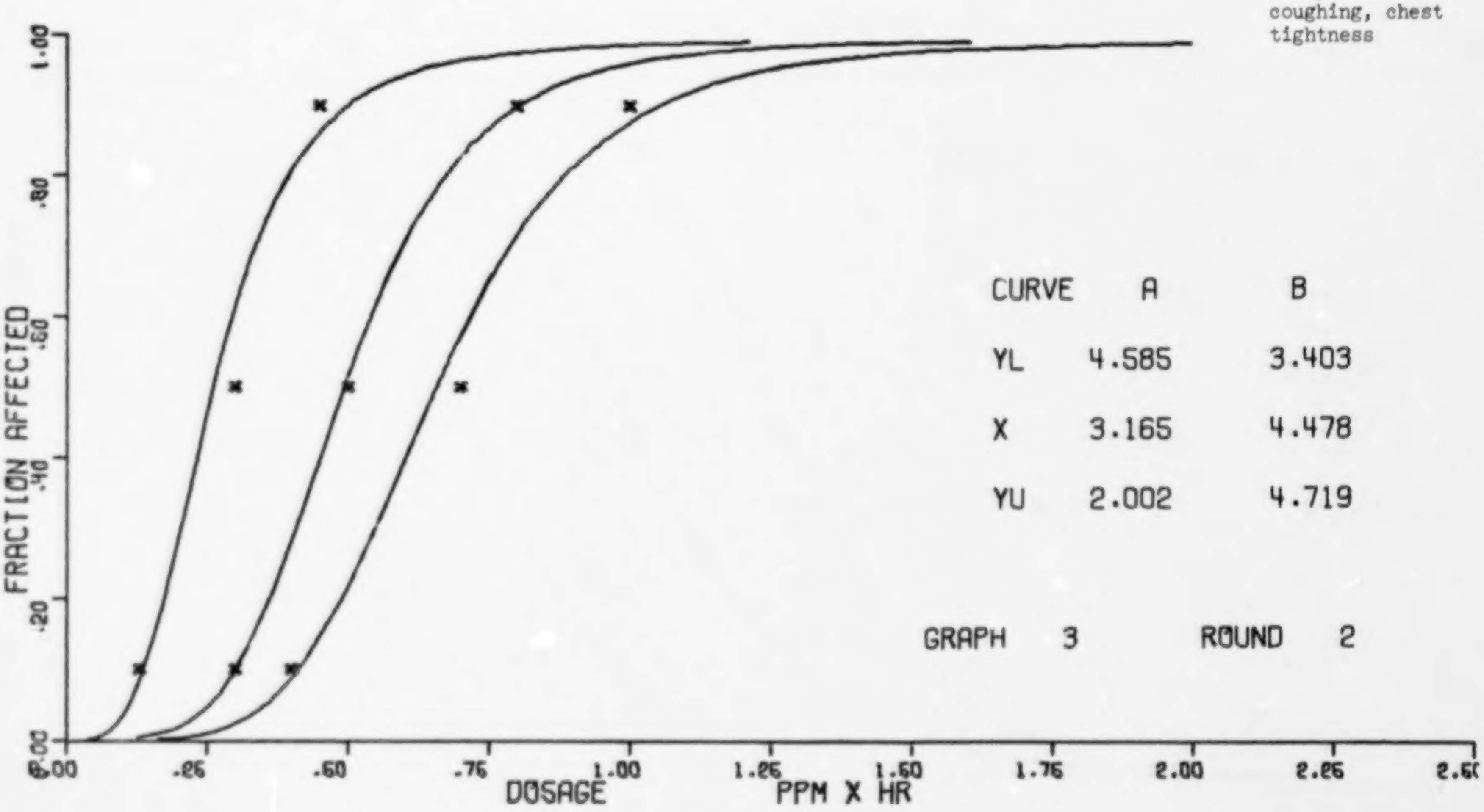
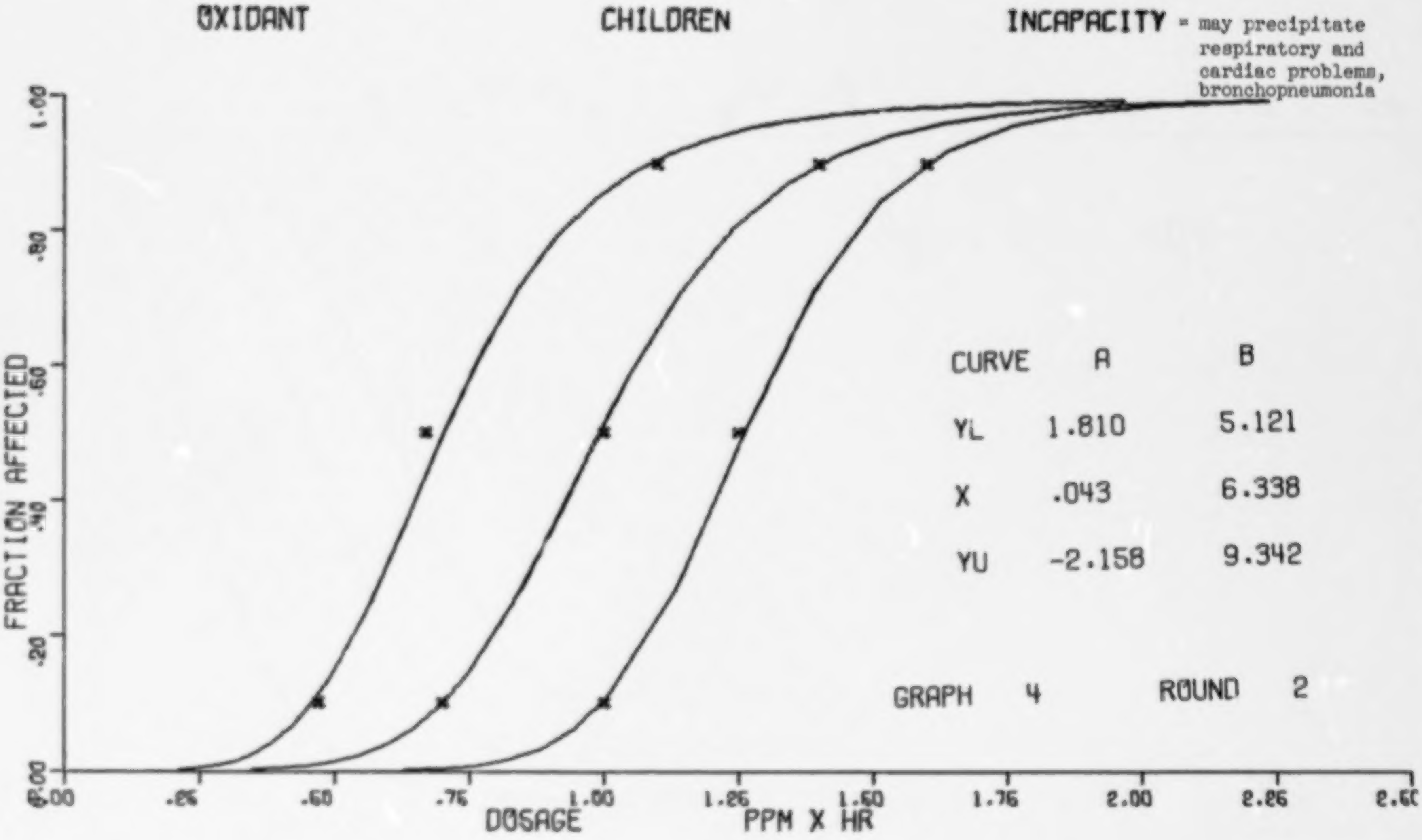
G. Influenza 103-105
H. Upper Respiratory Infection 106-108
I. Asthma 109-111
J. Acute Viral Bronchitis 112-114
K. Acute Bacterial Pneumonia 115-117
L. Chronic Respiratory Diseases 118-120
M. Mild Chronic Obstructive Lung Disease 121-123
N. Severe Chronic Obstructive Lung Disease 124-126

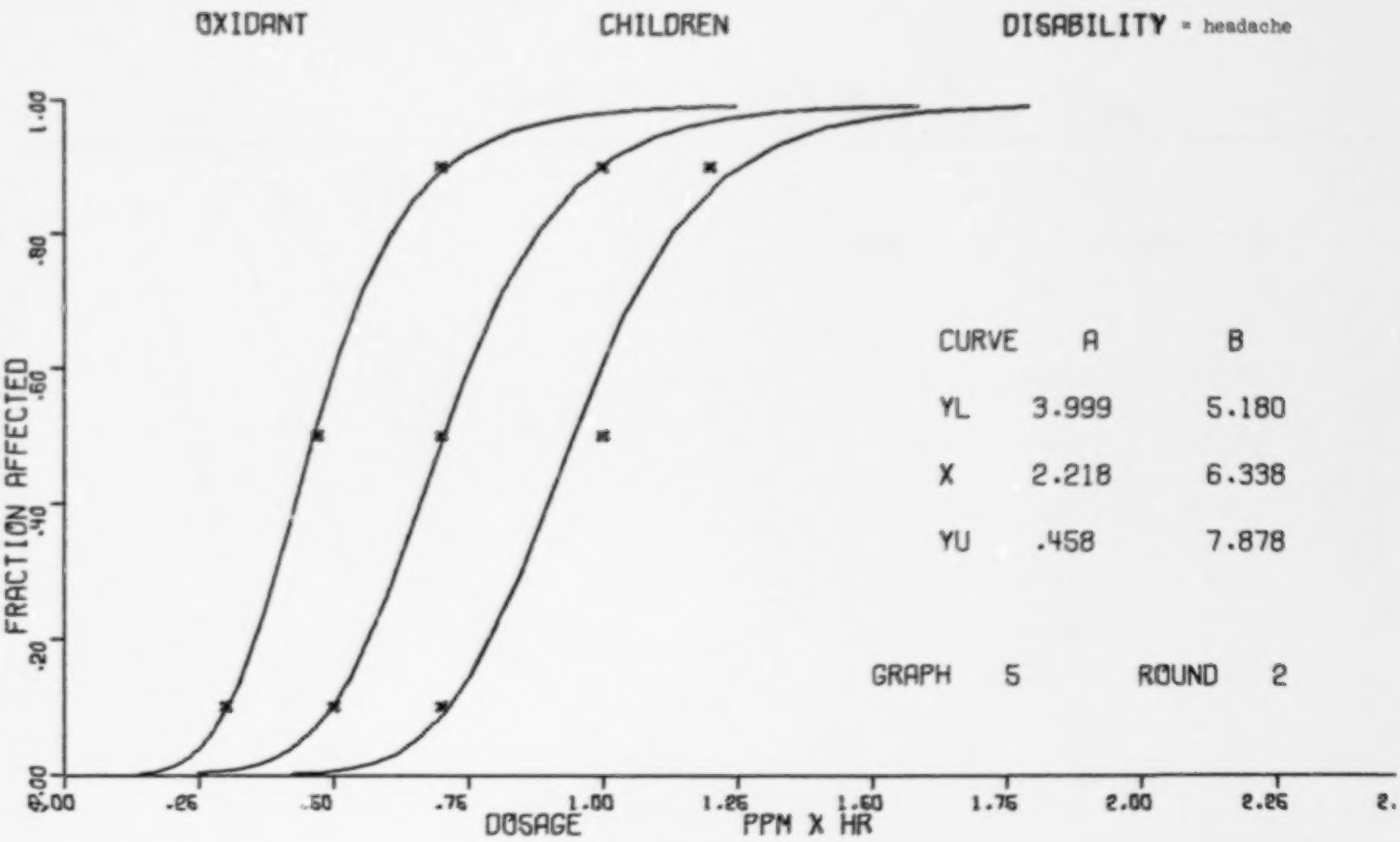

OXIDANT
NORMAL
INCAPACITY = may precipitate respiratory and cardiac problems, bronchopneumonia
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.5
DOSAGE
PPM X HR
CURVE A B
YL 1.343 4.030
X -.357 6.537
YU -2.287 7.424
GRAPH 1
ROUND 2

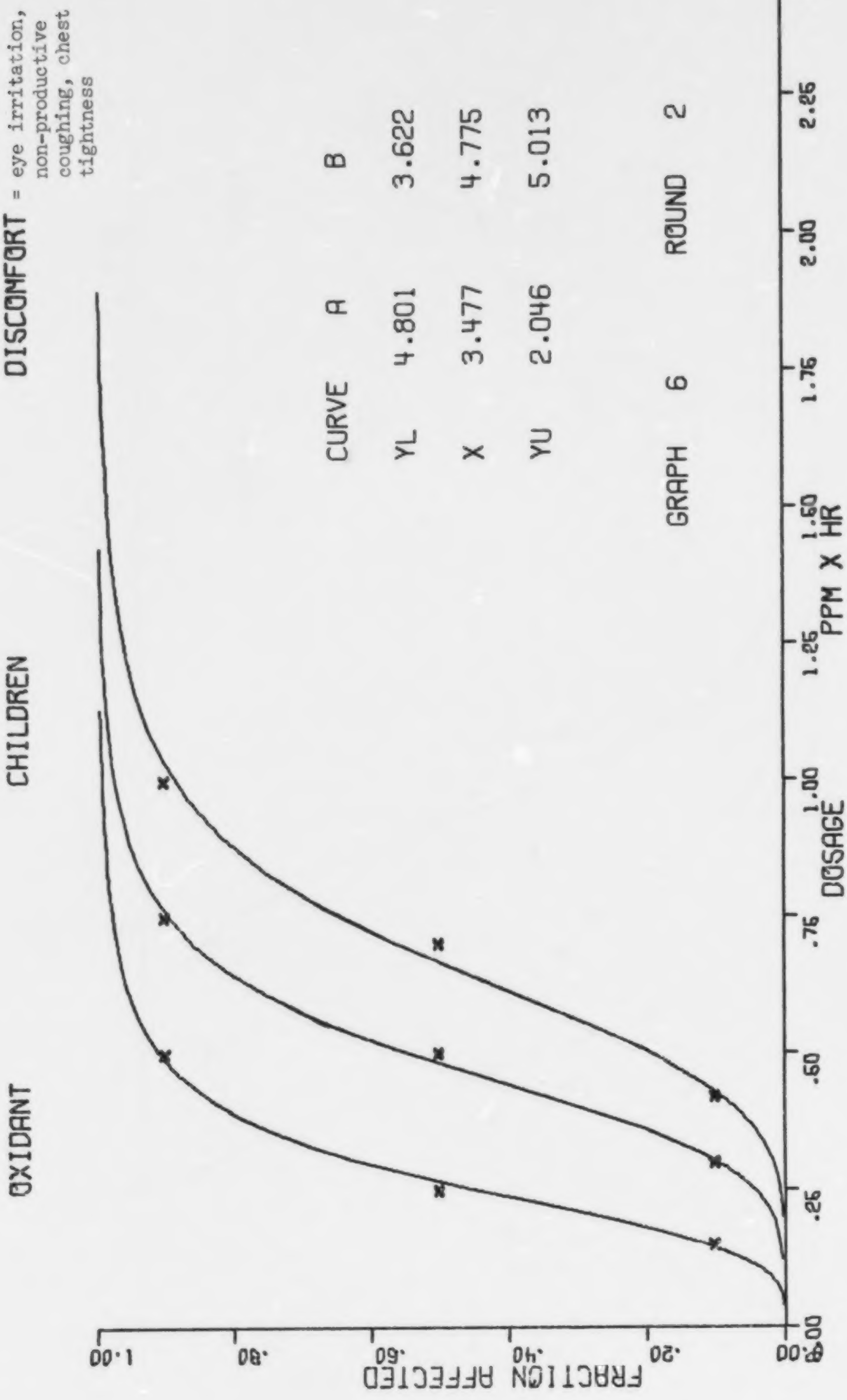

OXIDANT
NORMAL
DISABILITY = headache
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.
CURVE A B
YL 2.865 3.732
X 1.691 4.550
YU .030 5.869
GRAPH 2
ROUND 2

OXIDANT NORMAL DISCOMFORT = eye irritation, non-productive coughing, chest tightness




OXIDANT
CHILDREN
INCAPACITY = may precipitate respiratory and cardiac problems, bronchopneumonia
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
CURVE A B
YL 1.810 5.121
X .043 6.338
YU -2.158 9.342
GRAPH 4
ROUND 2

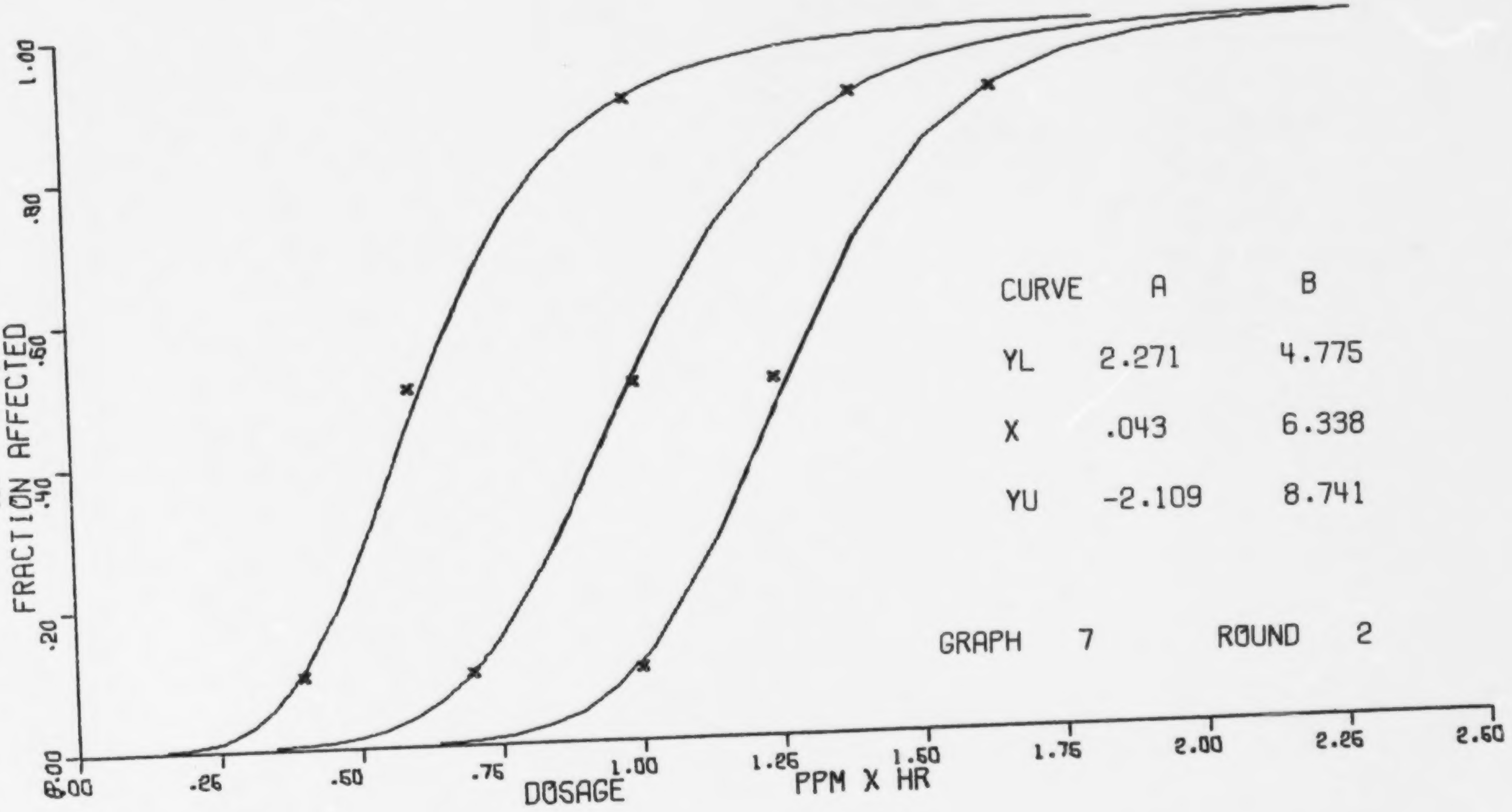

OXIDANT
CHILDREN
DISABILITY = headache
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.
DOSAGE
PPM X HR
CURVE A B
YL 3.999 5.180
X 2.218 6.338
YU .458 7.878
GRAPH 5
ROUND 2

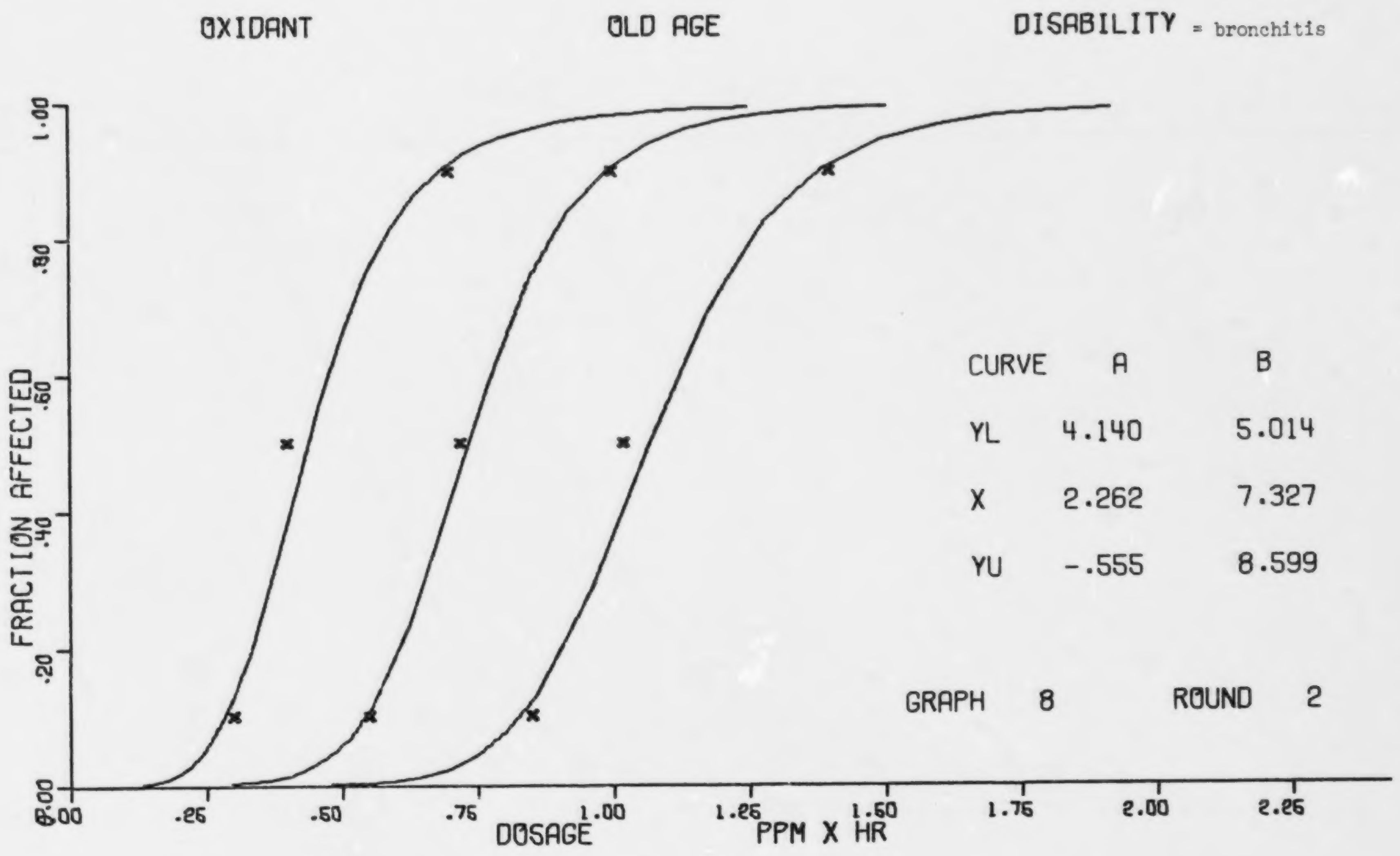

OXIDANT
CHILDREN
DISCOMFORT = eye irritation, non-productive coughing, chest tightness
CURVE A B
YL 4.801 3.622
X 3.477 4.775
YU 2.046 5.013
GRAPH 6 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE PPM X HR
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.

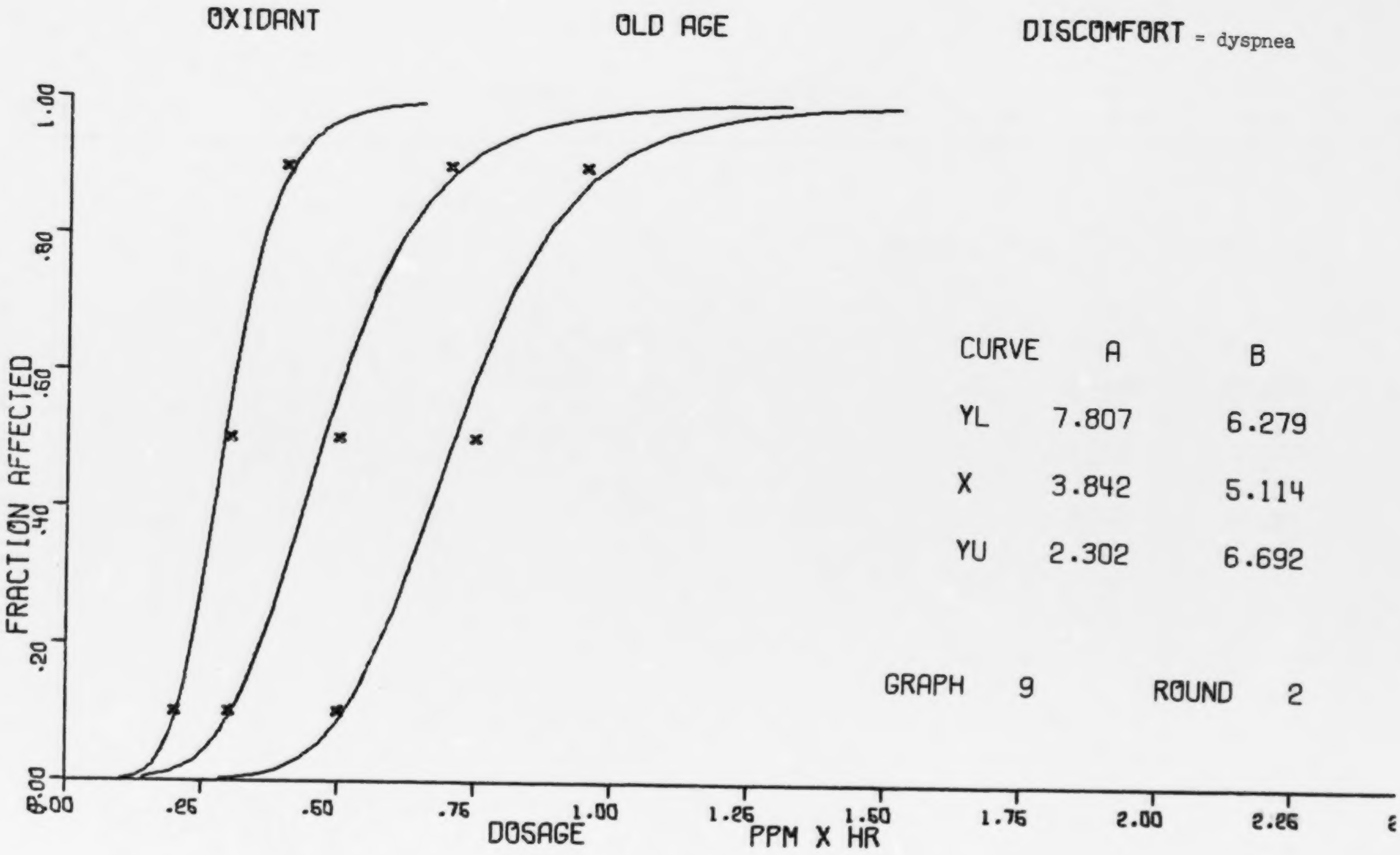
OXIDANT

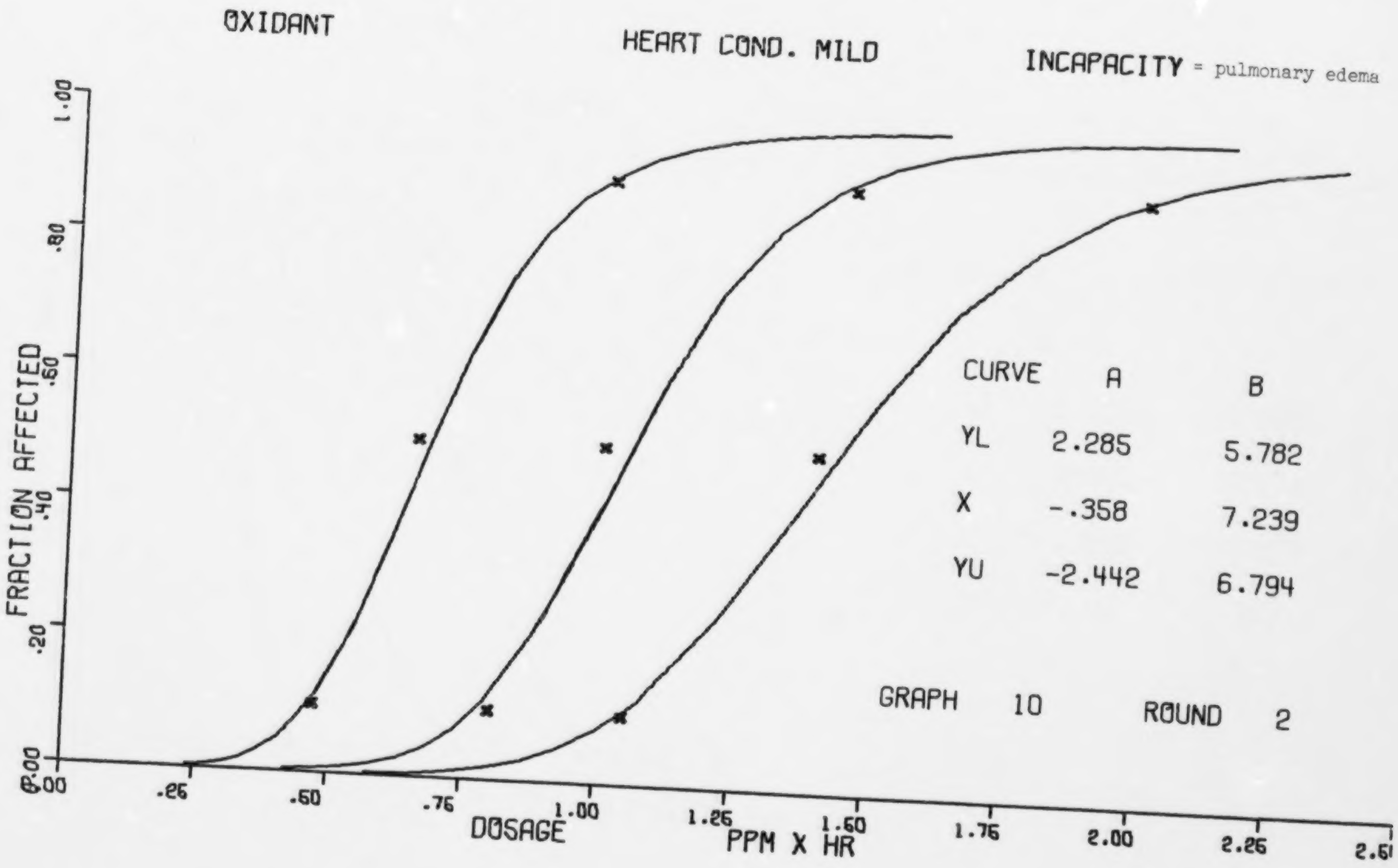
OLD AGE

INCAPACITY = acute respiratory failure

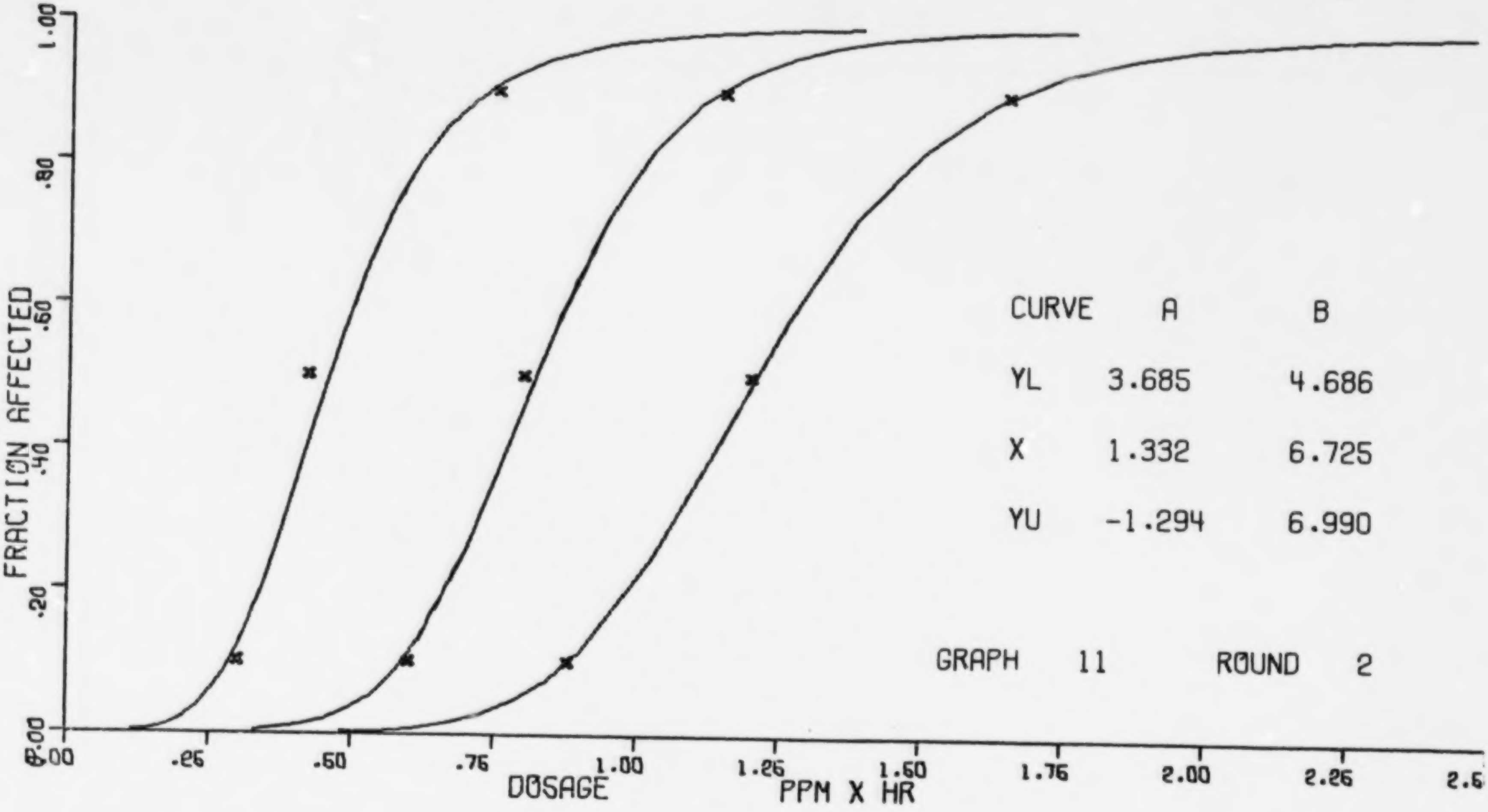



OXIDANT
OLD AGE
DISABILITY = bronchitis
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 4.140 5.014
X 2.262 7.327
YU -.555 8.599
GRAPH 8
ROUND 2


OXIDANT
OLD AGE
DISCOMFORT = dyspnea
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 7.807 6.279
X 3.842 5.114
YU 2.302 6.692
GRAPH 9
ROUND 2


ØXIDANT
HEART CØND. MILD
INCAPACITY = pulmonary edema
CURVE A B
YL 2.285 5.782
X -.358 7.239
YU -2.442 6.794
GRAPH 10
RØUND 2
FRACTIØN AFFECTED
0.00
.20
.40
.60
.80
1.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.5
DØSAGE
PPM X HR

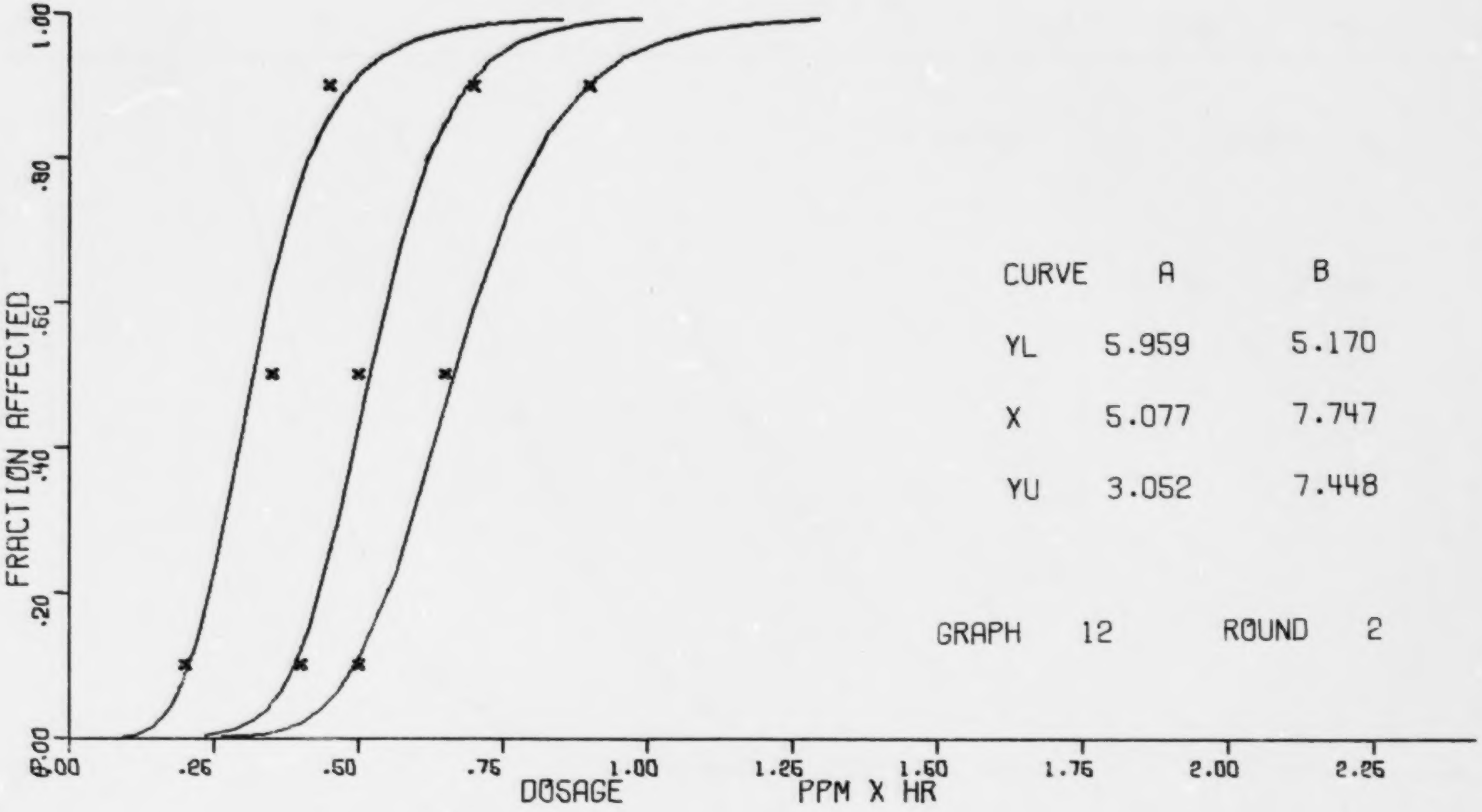
OXIDANT HEART COND. MILD DISABILITY = congestive heart failure

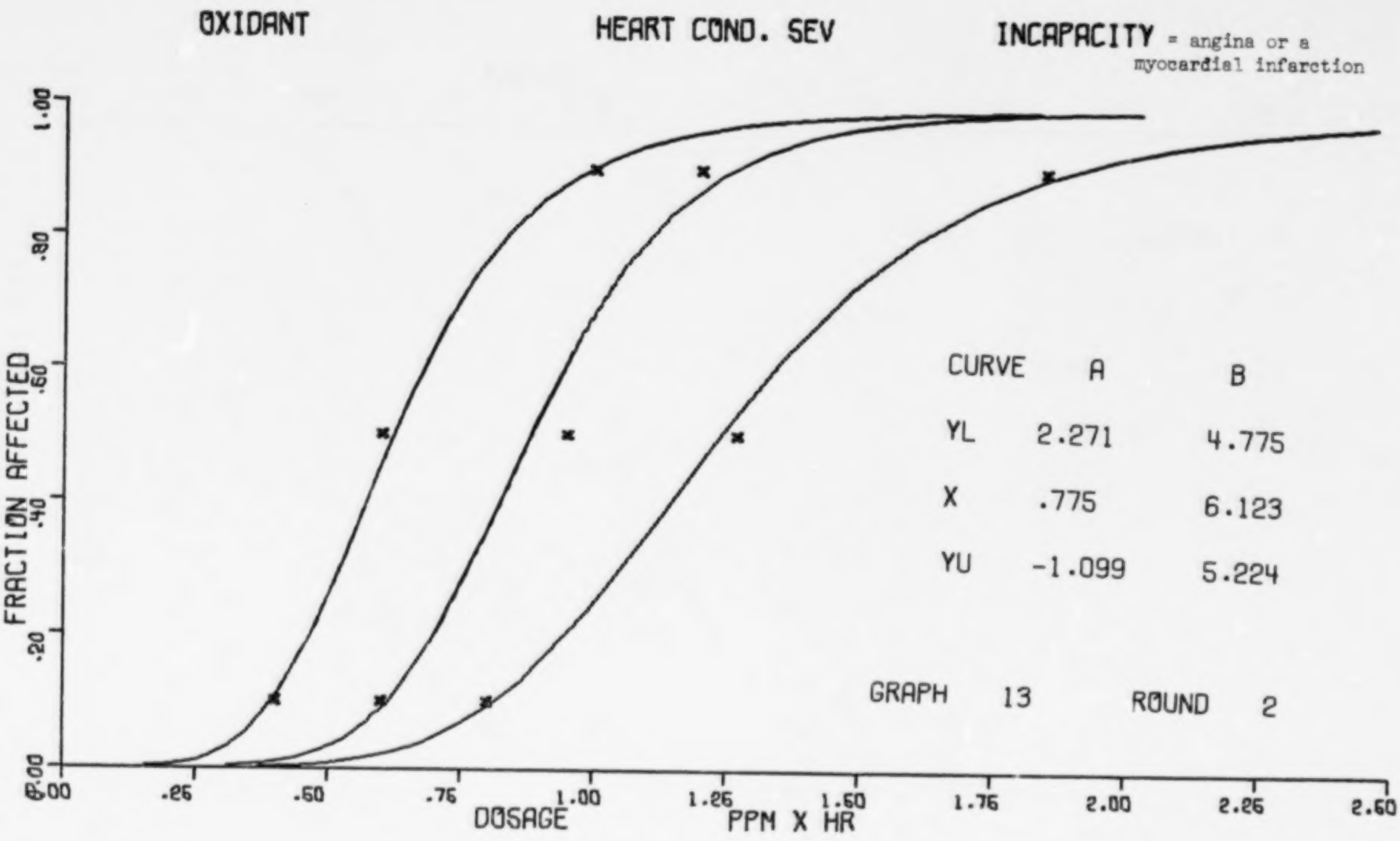


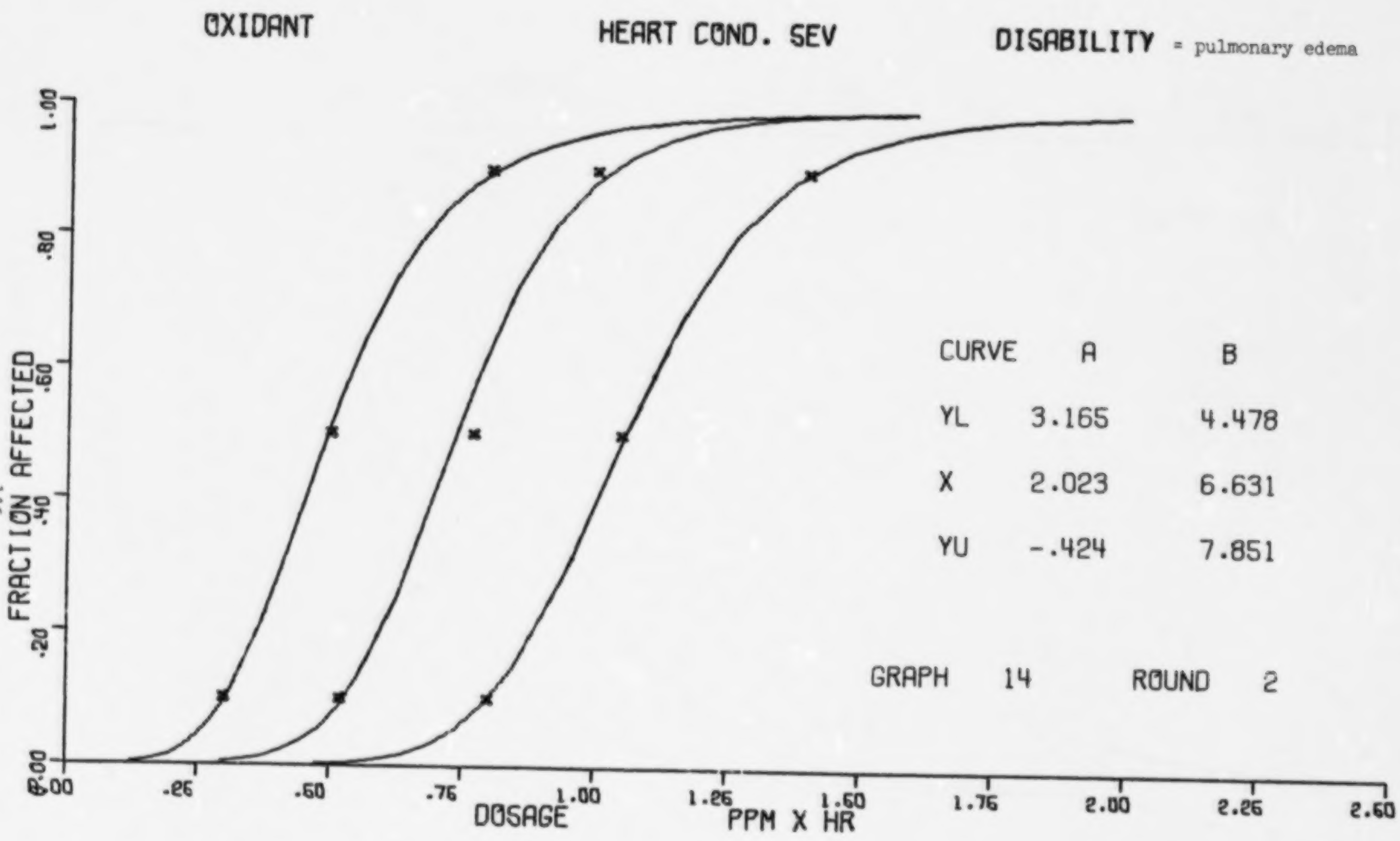
CURVE	A	B
YL	3.685	4.686
X	1.332	6.725
YU	-1.294	6.990

GRAPH 11 ROUND 2

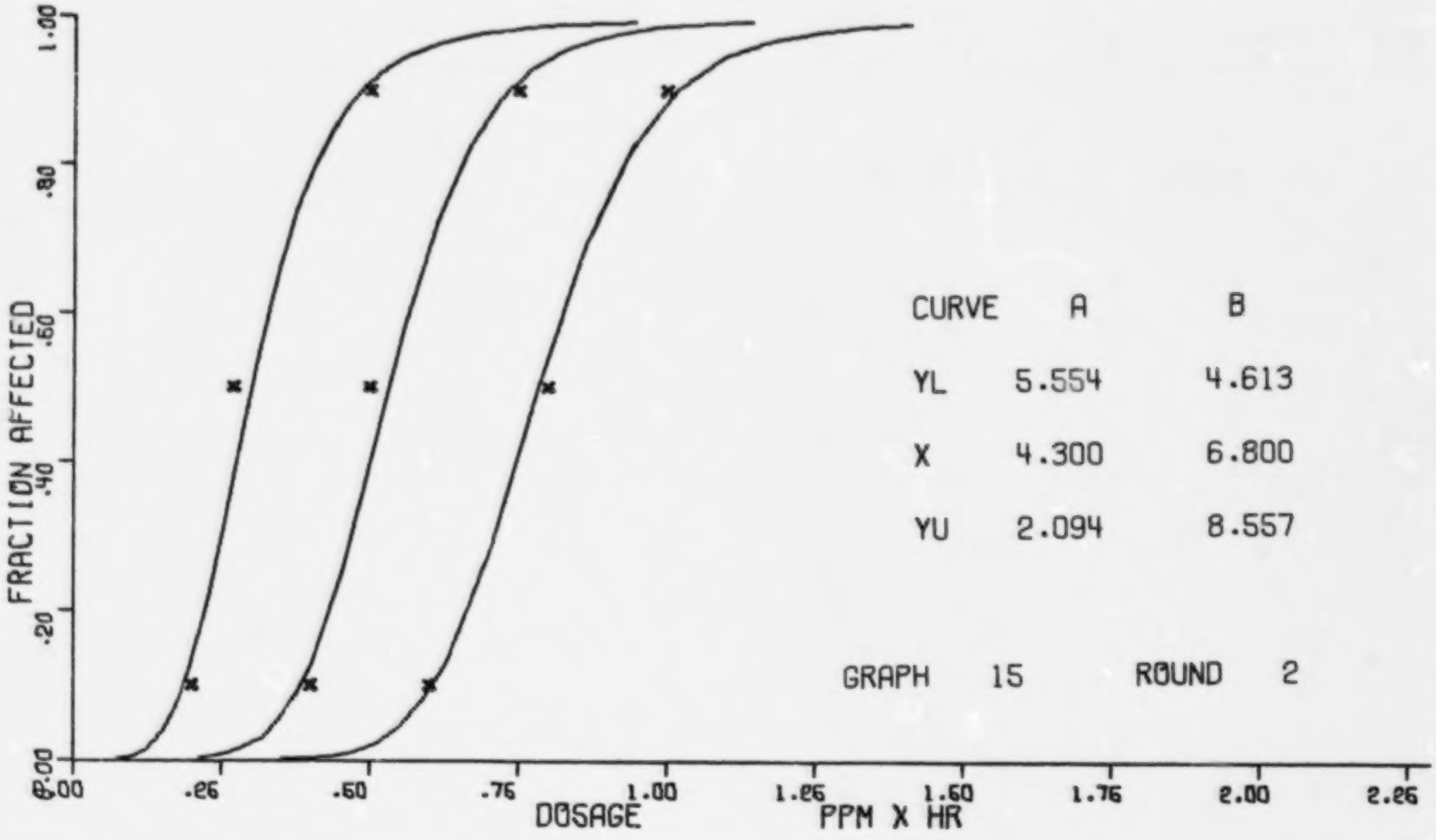
OXIDANT HEART COND. MILD **DISCOMFORT** = dyspnea

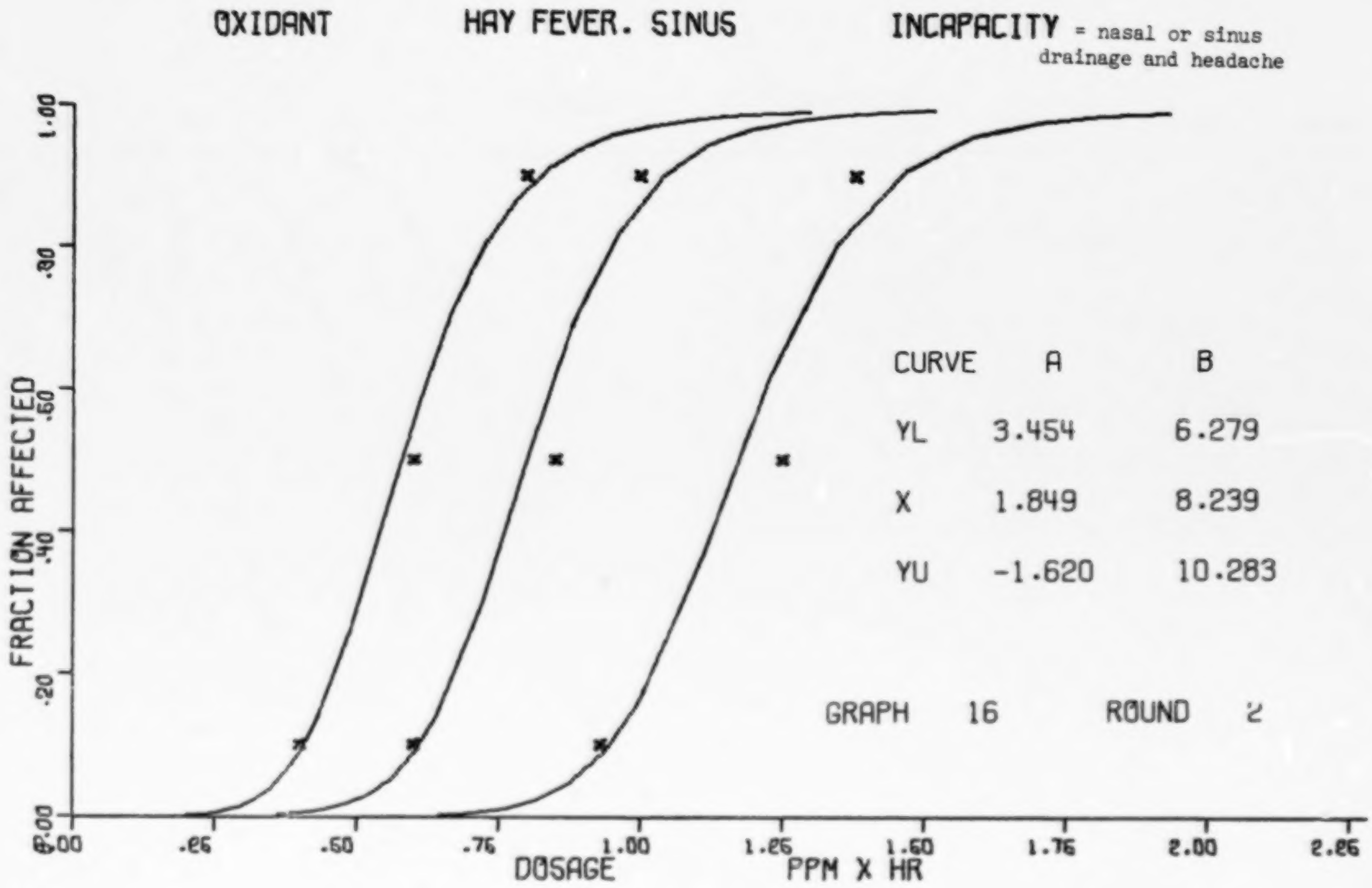


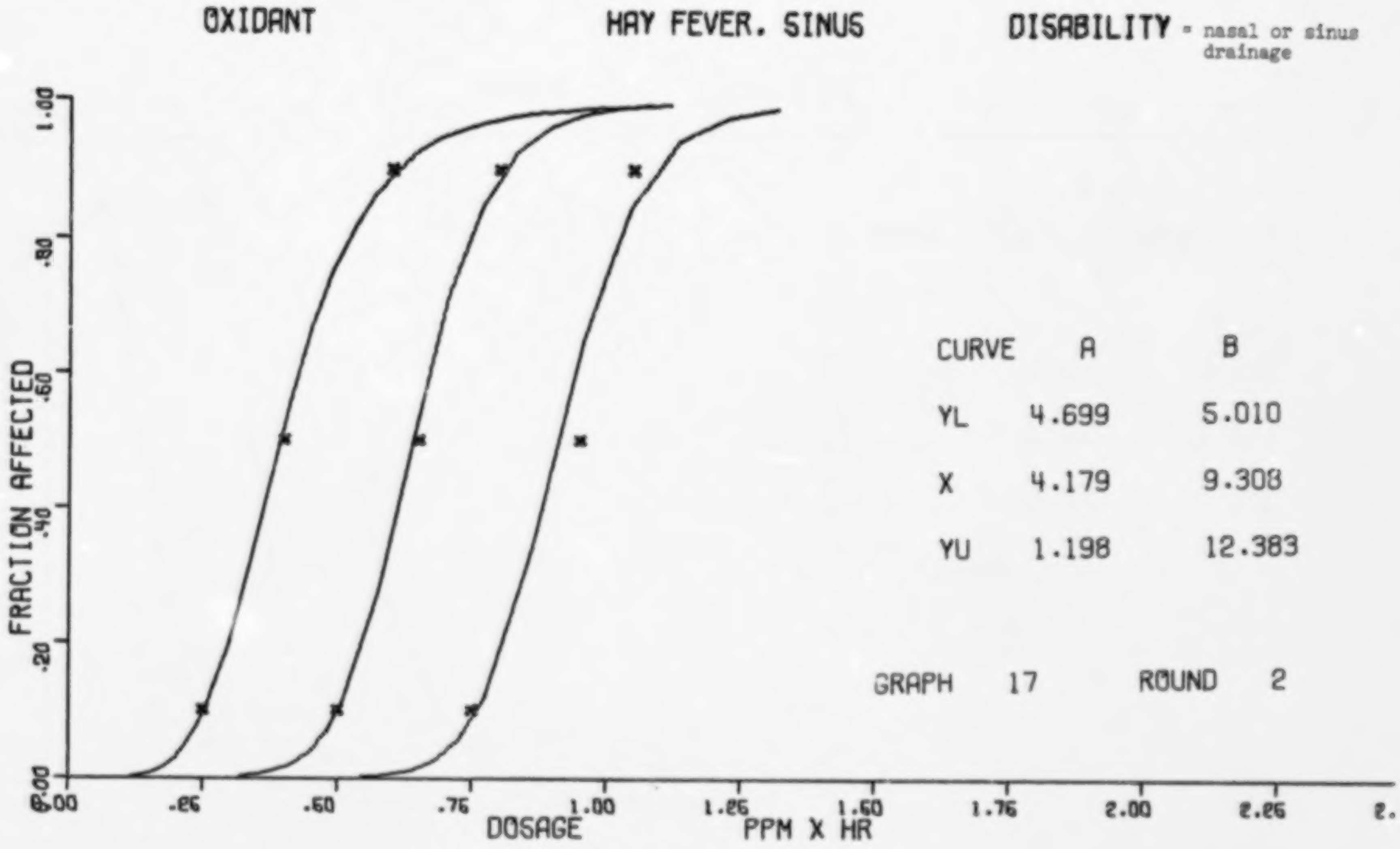

OXIDANT
HEART COND. SEV
INCAPACITY = angina or a myocardial infarction
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
DOSAGE PPM X HR
CURVE A B
YL 2.271 4.775
X .775 6.123
YU -1.099 5.224
GRAPH 13 ROUND 2

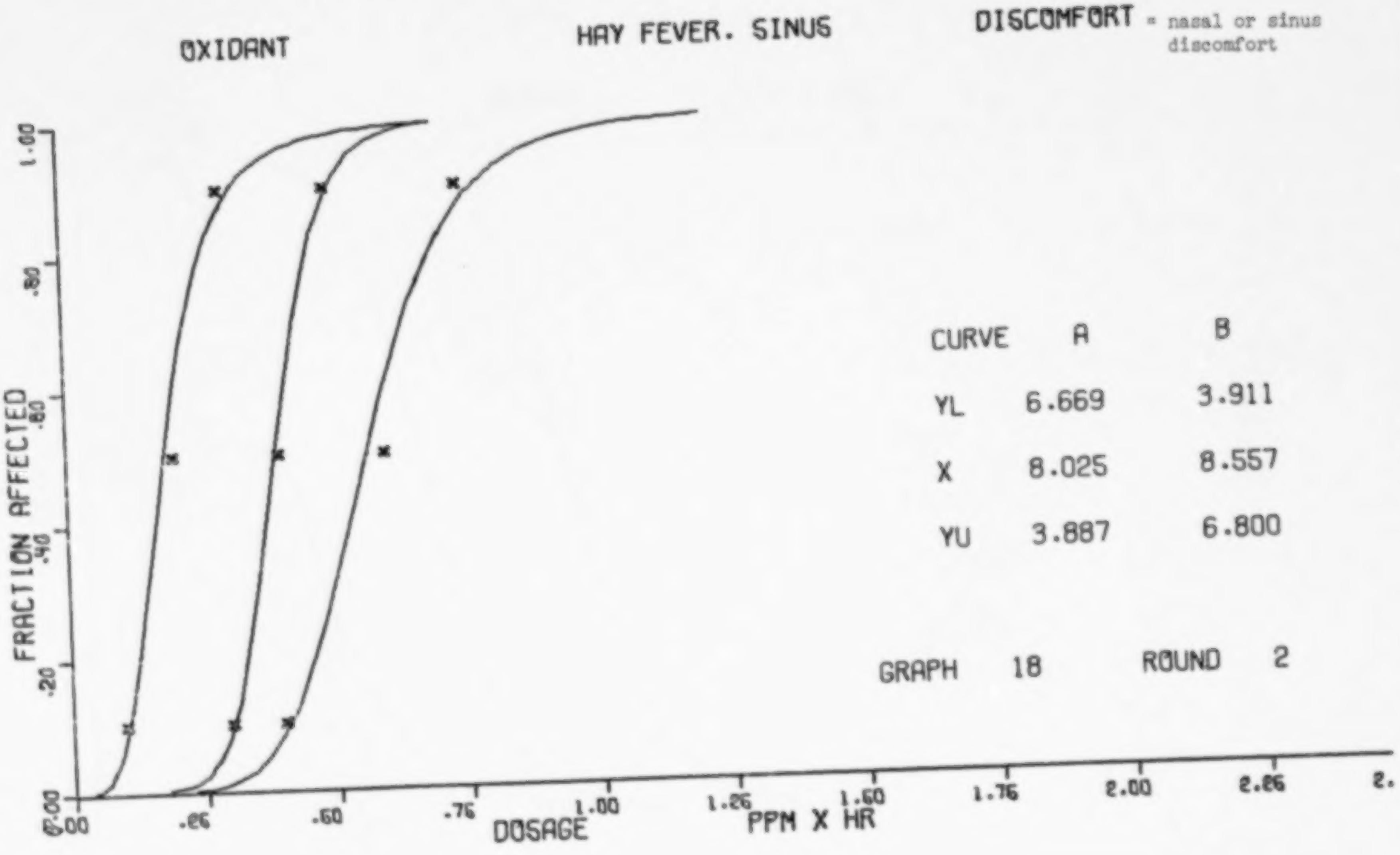

OXIDANT
HEART COND. SEV
DISABILITY = pulmonary edema
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
CURVE A B
YL 3.165 4.478
X 2.023 6.631
YU -.424 7.851
GRAPH 14
ROUND 2

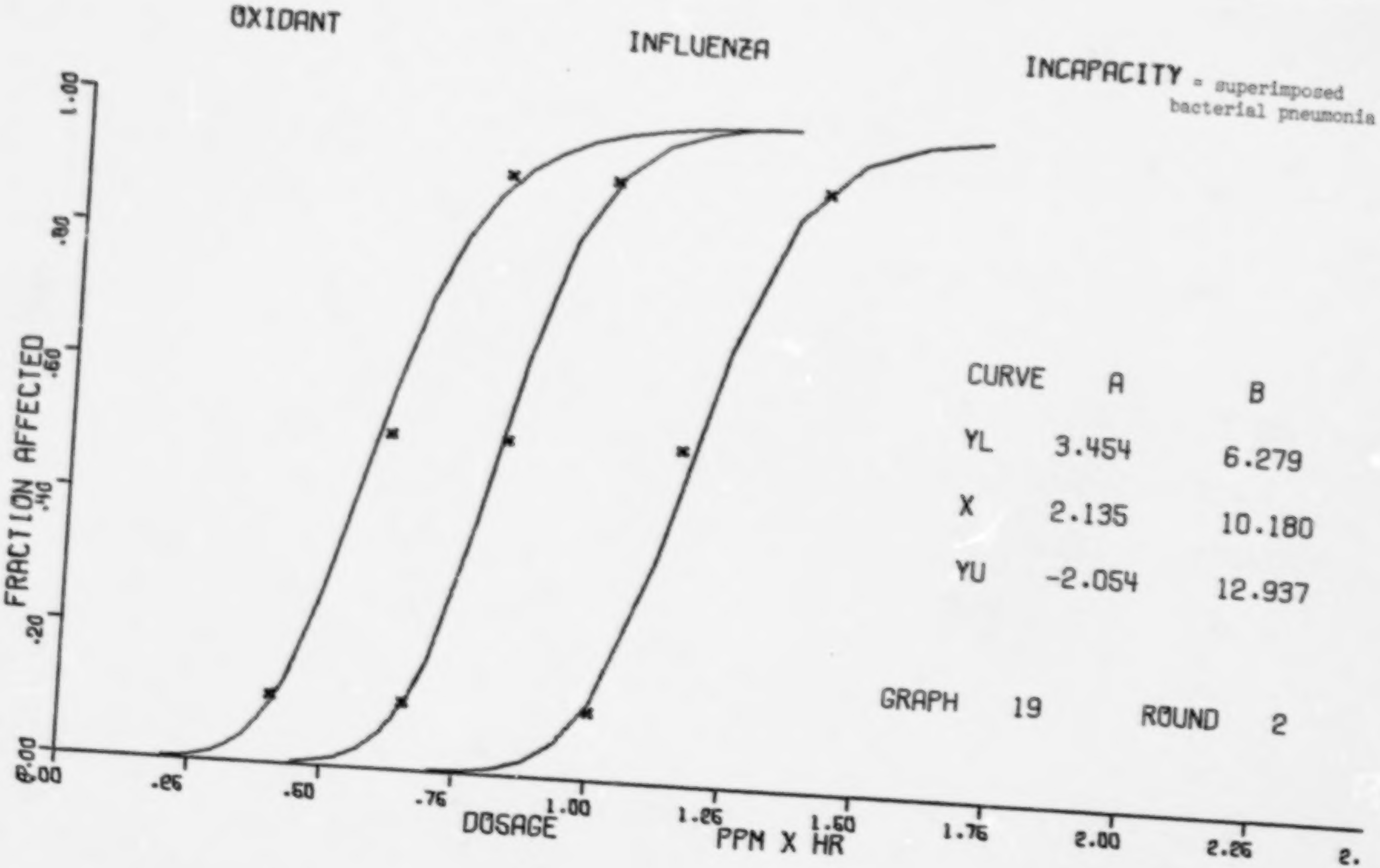
OXIDANT HEART COND. SEV DISCOMFORT = worsening congestive heart failure

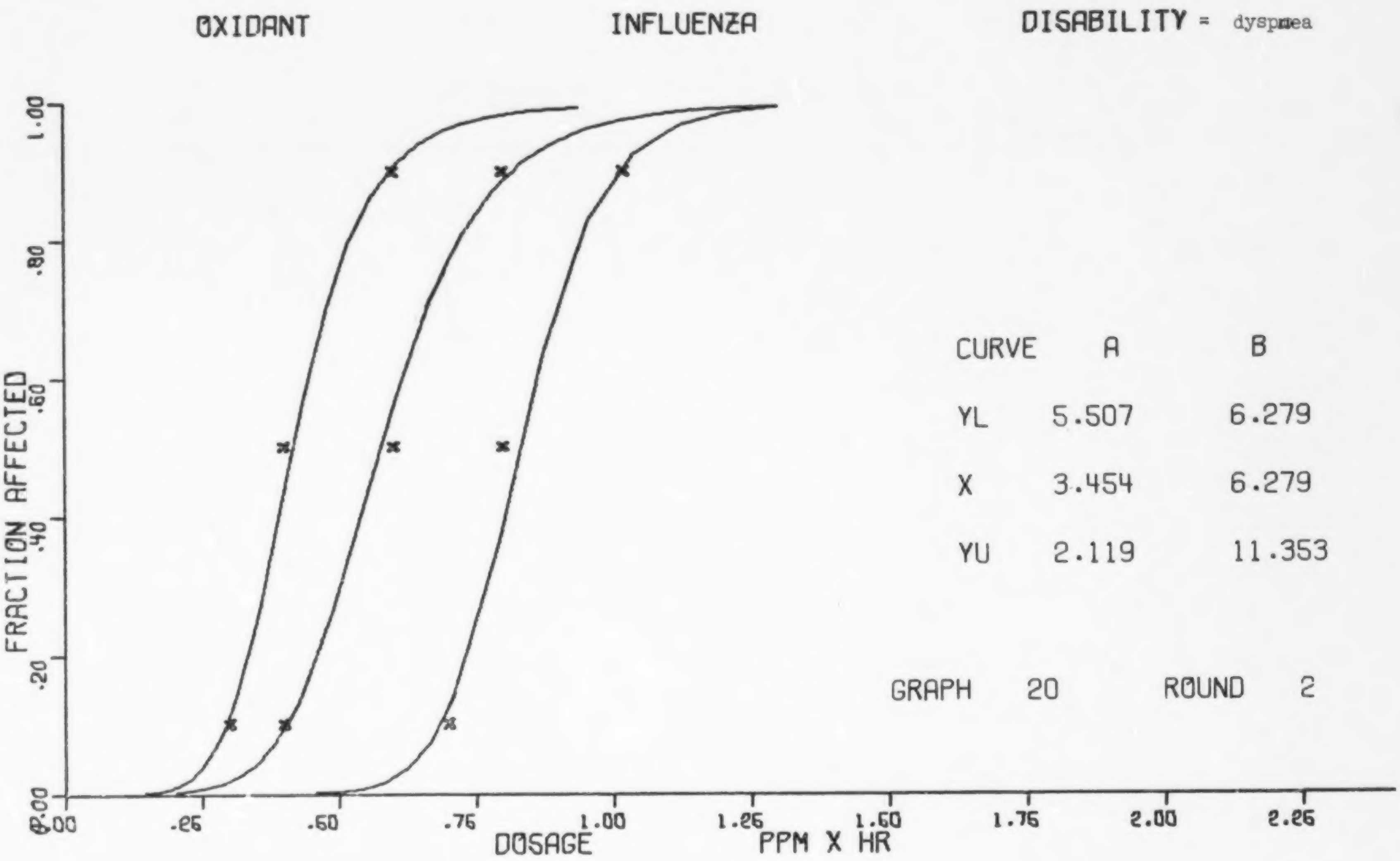


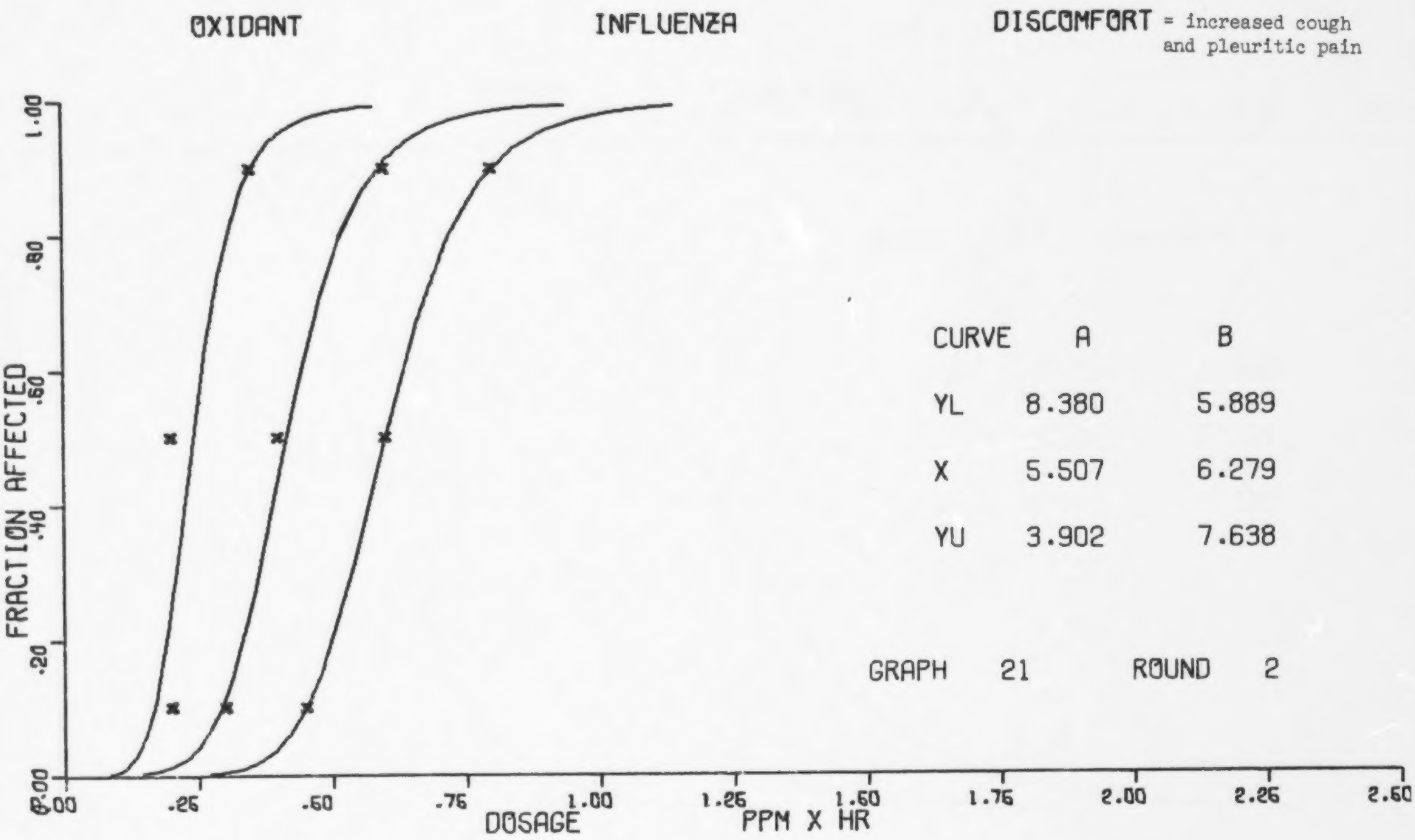

OXIDANT
HAY FEVER. SINUS
INCAPACITY = nasal or sinus drainage and headache
CURVE A B
YL 3.454 6.279
X 1.849 8.239
YU -1.620 10.283
GRAPH 16 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25

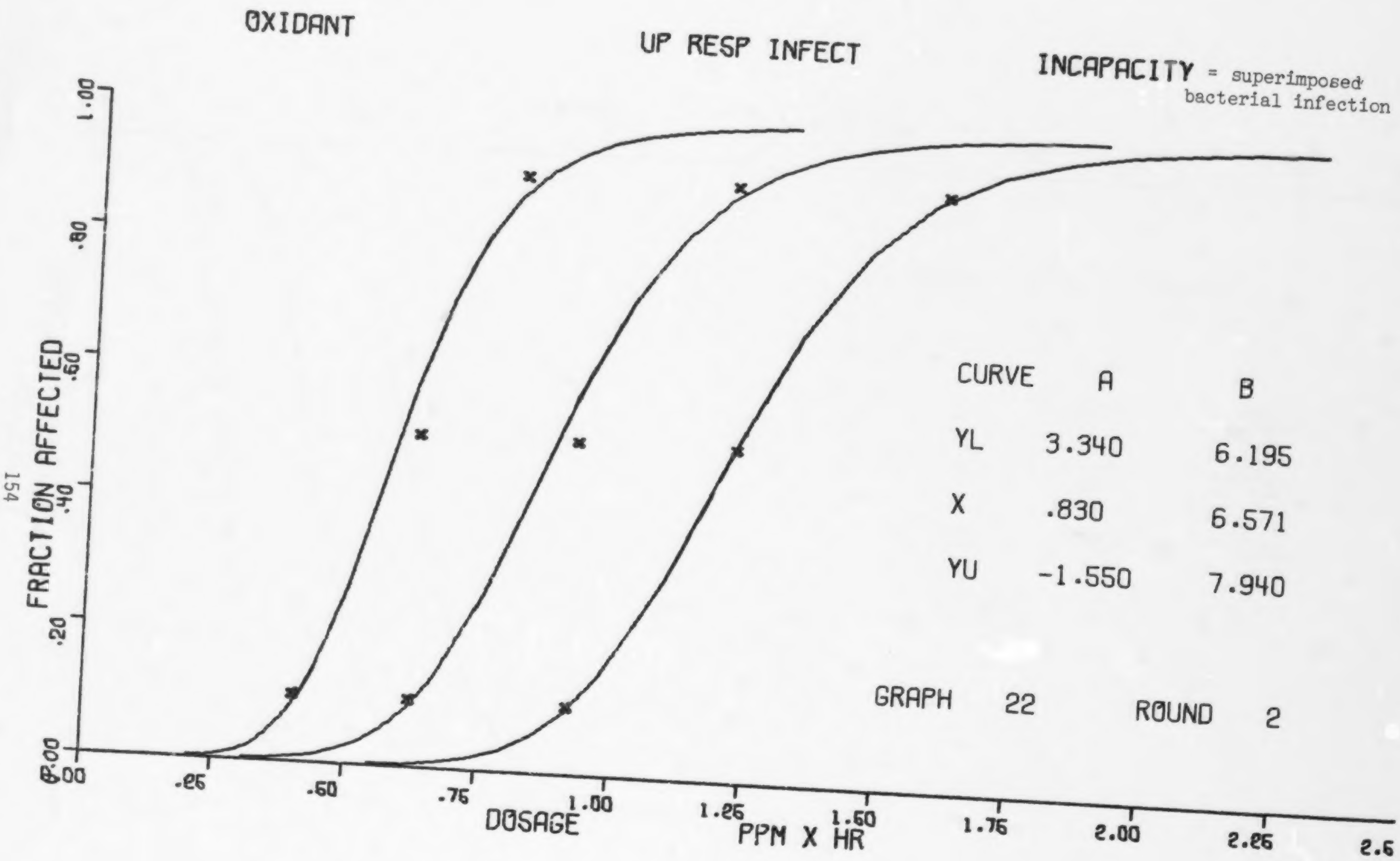

OXIDANT
HAY FEVER. SINUS
DISABILITY = nasal or sinus drainage
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.
CURVE A B
YL 4.699 5.010
X 4.179 9.308
YU 1.198 12.383
GRAPH 17
ROUND 2


OXIDANT
HAY FEVER. SINUS
DISCOMFORT = nasal or sinus discomfort
FRACTION AFFECTED
1.00
.80
.60
.40
.20
0.00
0.00
.26
.60
.76
1.00
1.26
1.60
1.76
2.00
2.26
2.
DOSAGE
PPM X HR
CURVE A B
YL 6.669 3.911
X 8.025 8.557
YU 3.887 6.800
GRAPH 18
ROUND 2

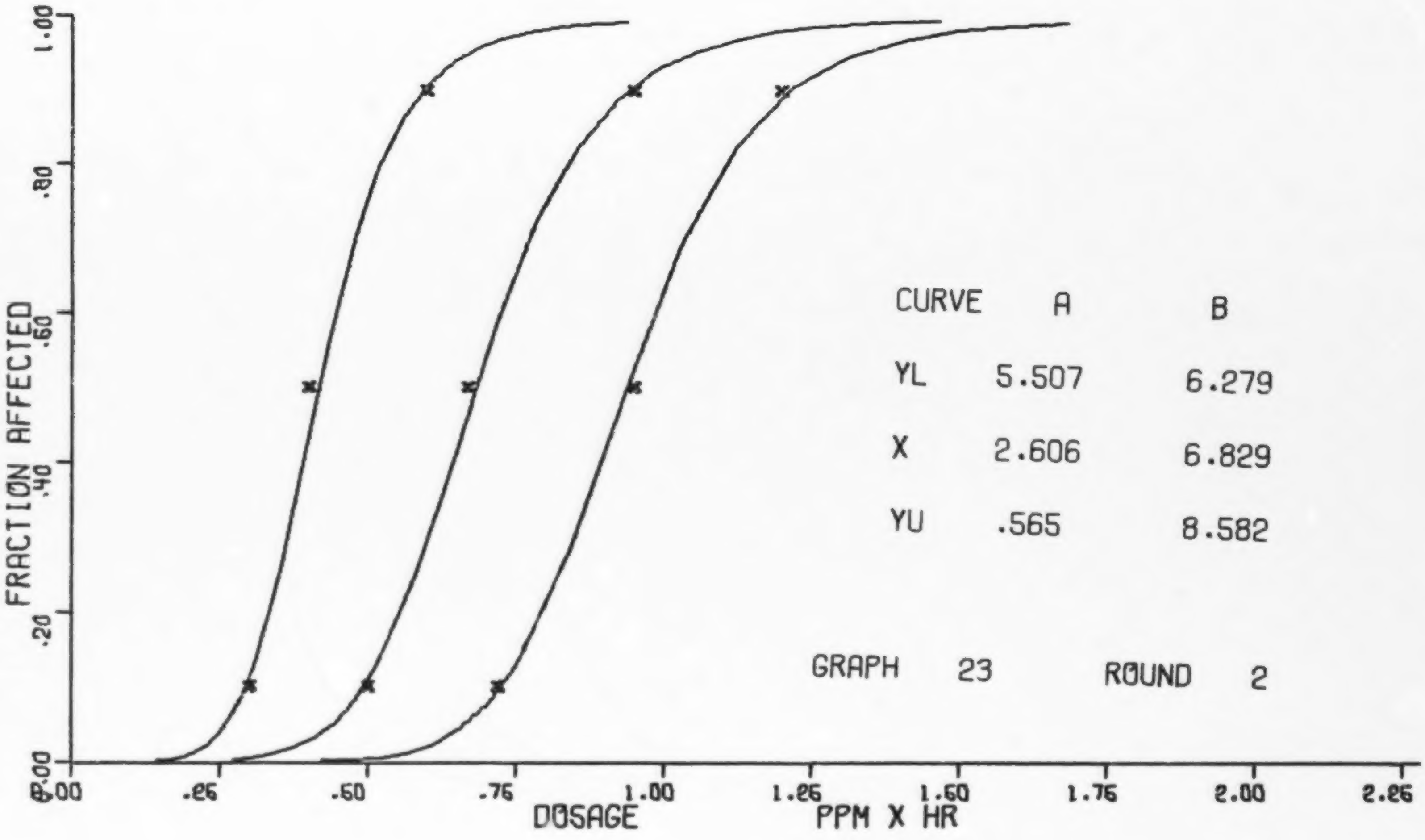

OXIDANT
INFLUENZA
INCAPACITY = superimposed bacterial pneumonia
FRACTION AFFECTED
1.00
.80
.60
.40
.20
0.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.
DOSAGE
PPM X HR
CURVE A B
YL 3.454 6.279
X 2.135 10.180
YU -2.054 12.937
GRAPH 19
ROUND 2


OXIDANT
INFLUENZA
DISABILITY = dyspnea
CURVE A B
YL 5.507 6.279
X 3.454 6.279
YU 2.119 11.353
GRAPH 20 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE PPM X HR


OXIDANT
INFLUENZA
DISCOMFORT = increased cough and pleuritic pain
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
DOSAGE
PPM X HR
CURVE A B
YL 8.380 5.889
X 5.507 6.279
YU 3.902 7.638
GRAPH 21
ROUND 2

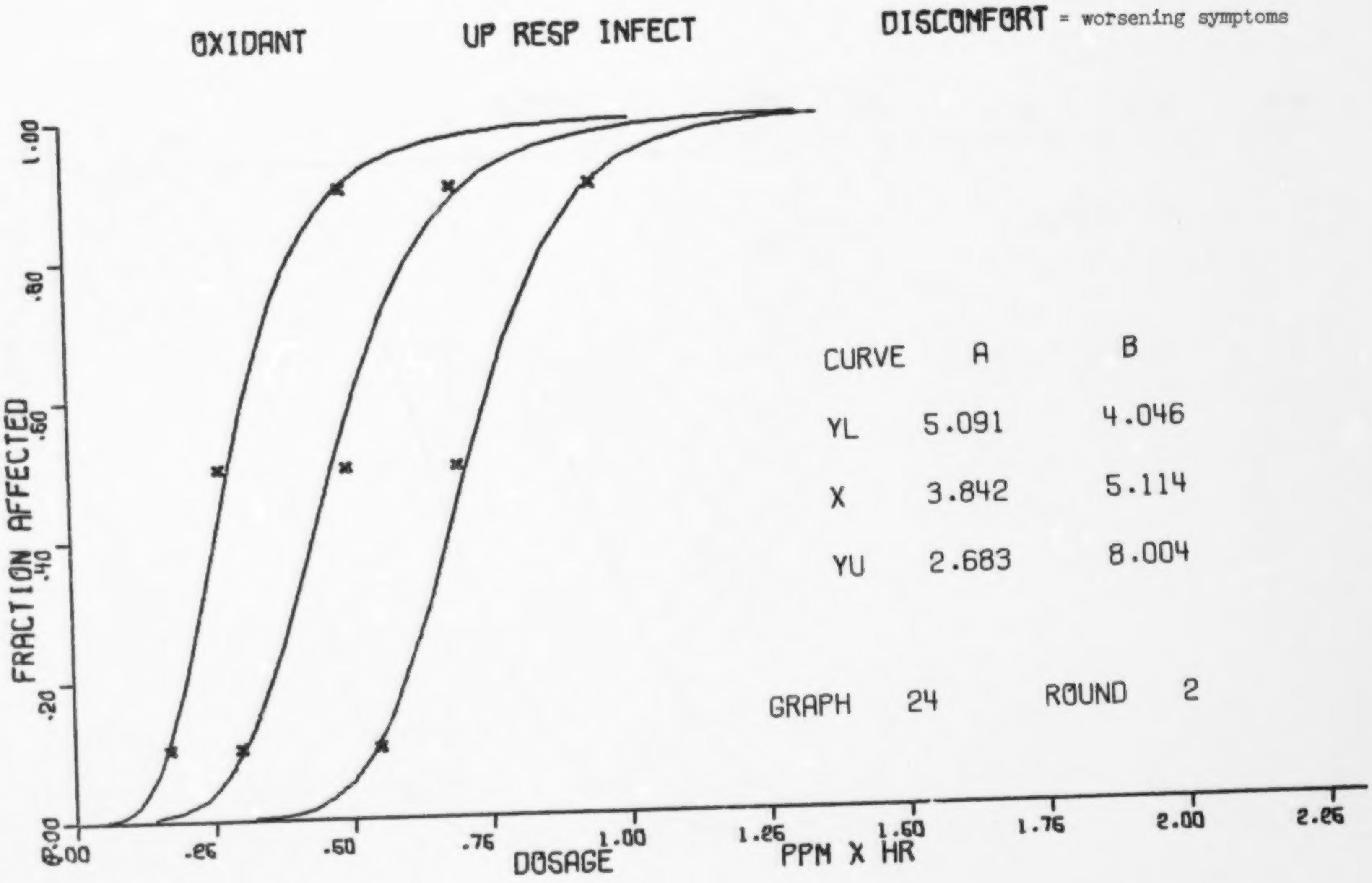

OXIDANT
UP RESP INFECT
INCAPACITY = superimposed bacterial infection
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.5
DOSAGE
PPM X HR
CURVE A B
YL 3.340 6.195
X .830 6.571
YU -1.550 7.940
GRAPH 22
ROUND 2

OXIDANT UP RESP INFECT DISABILITY = dyspnea, or need medication and rest

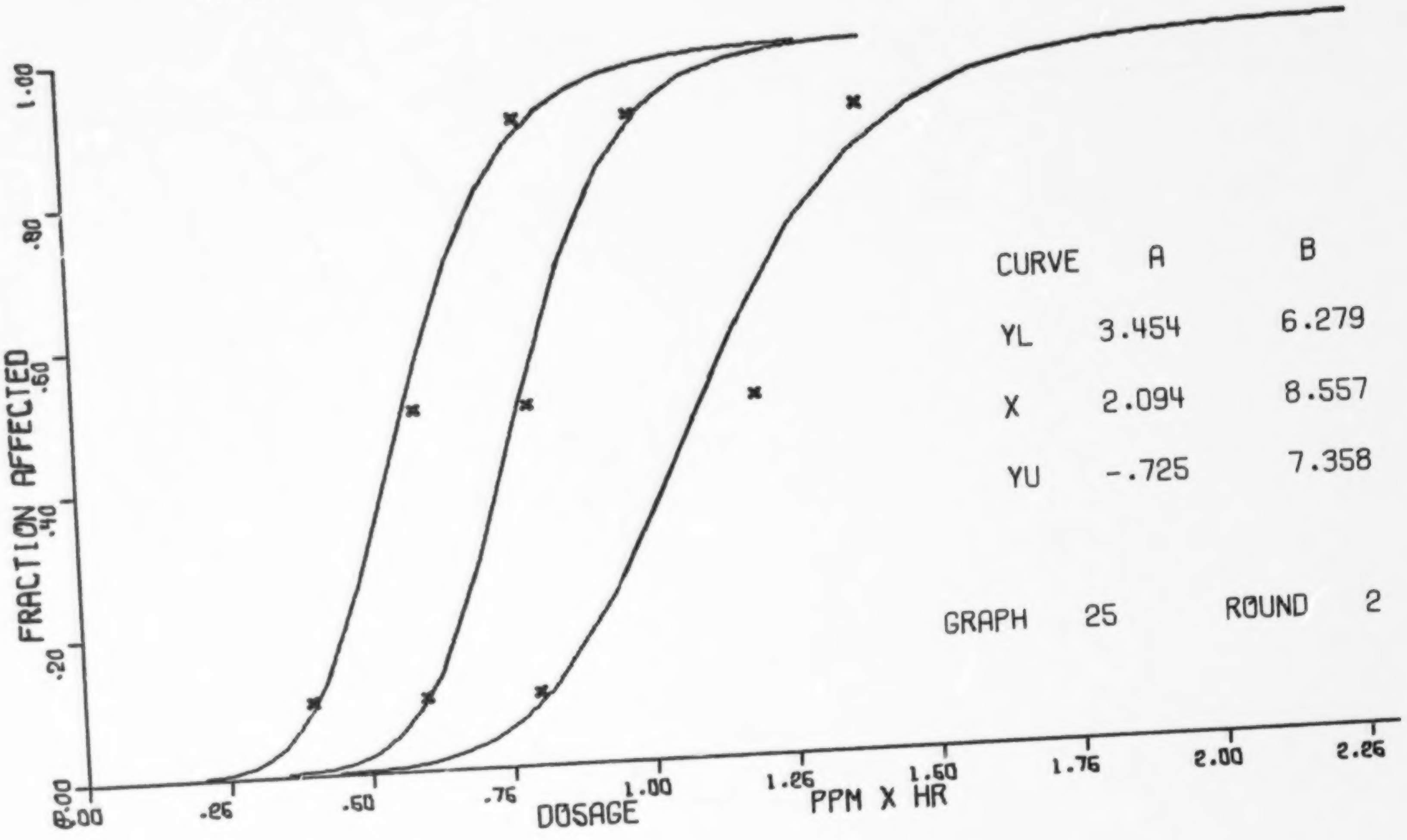


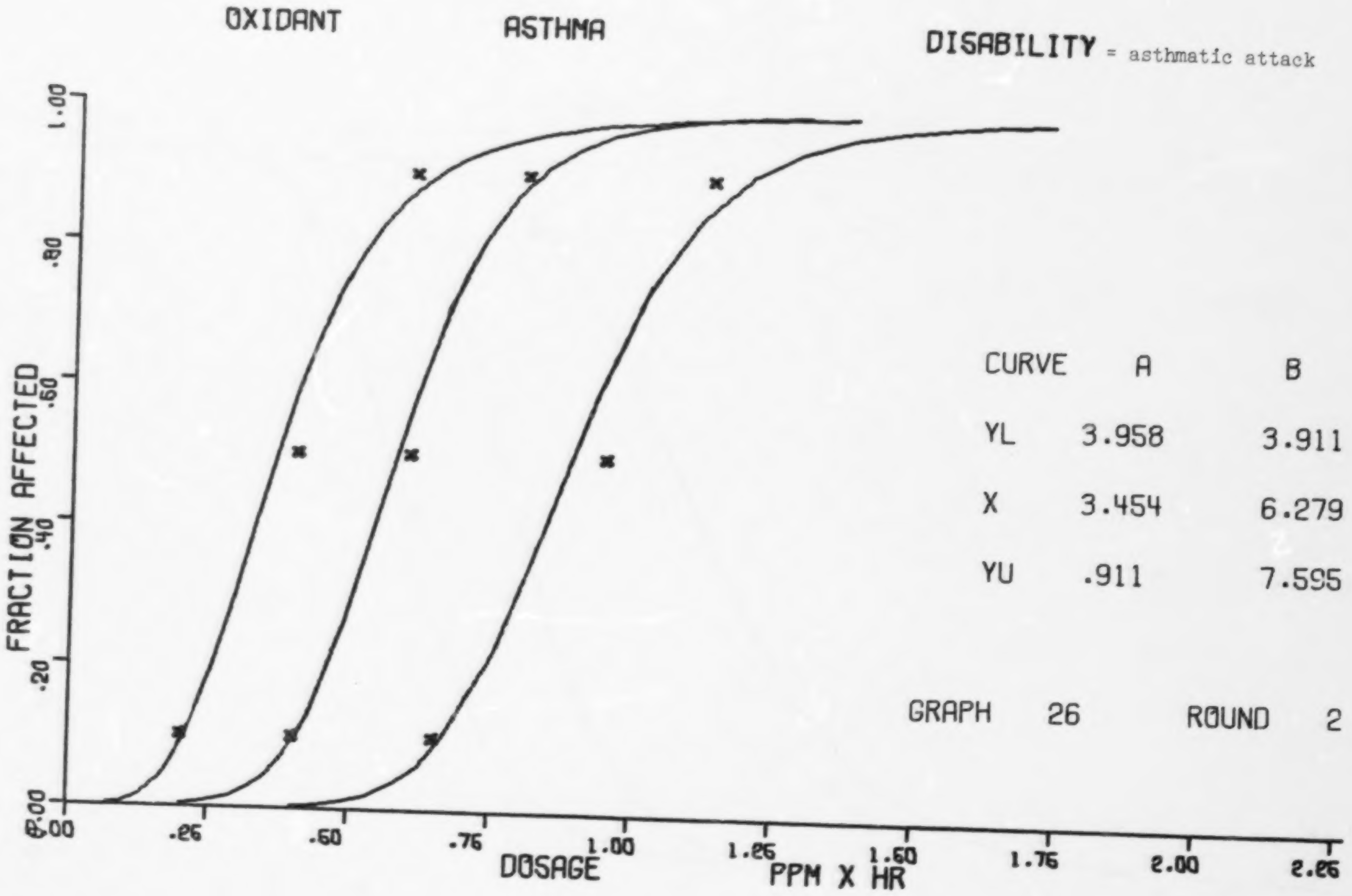
CURVE	A	B
YL	5.507	6.279
X	2.606	6.829
YU	.565	8.582

GRAPH 23 ROUND 2


OXIDANT
UP RESP INFECT
DISCONFORT = worsening symptoms
CURVE A B
YL 5.091 4.046
X 3.842 5.114
YU 2.683 8.004
GRAPH 24
ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25

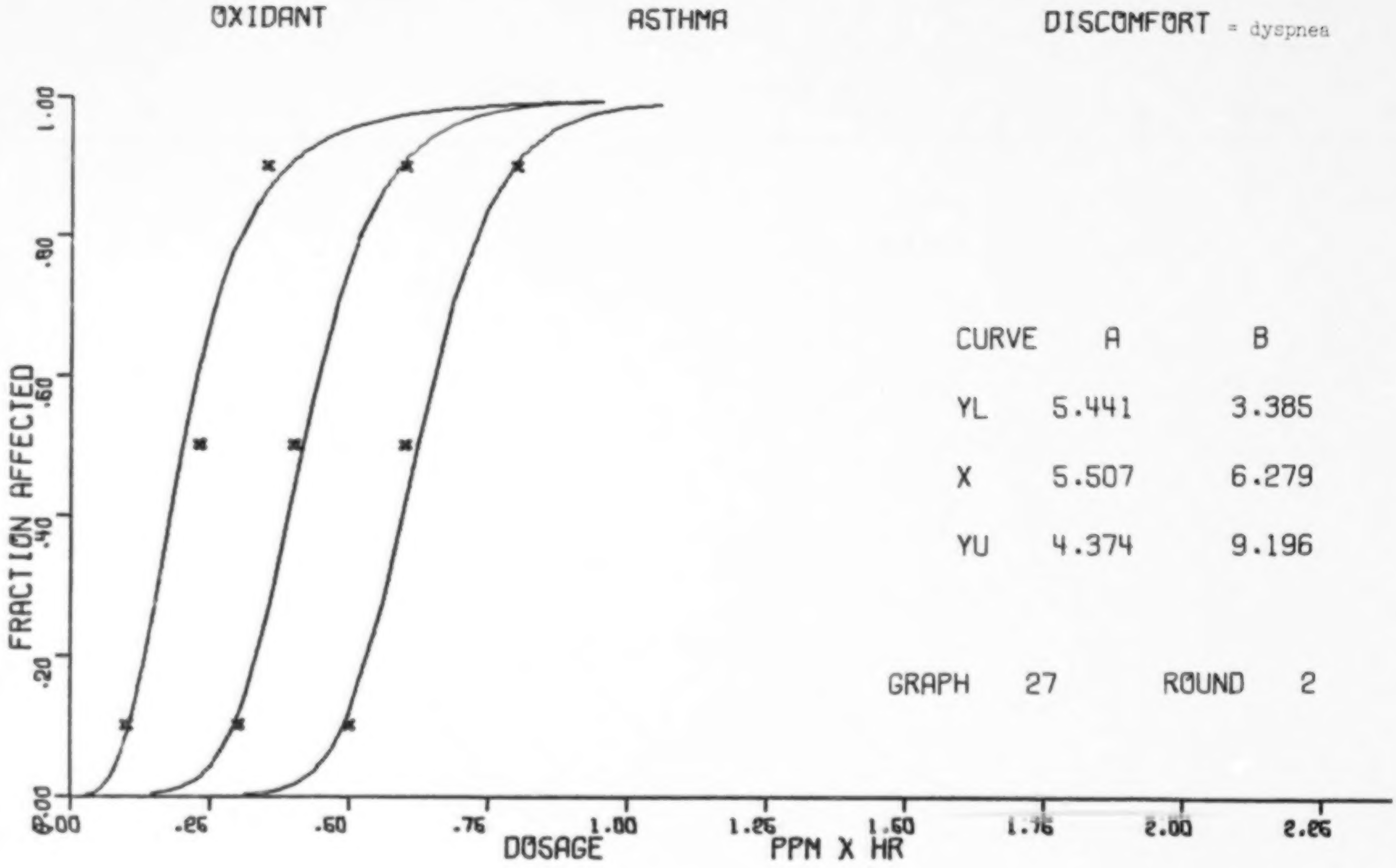
OXIDANT ASTHMA **INCAPACITY** = status asthmaticus

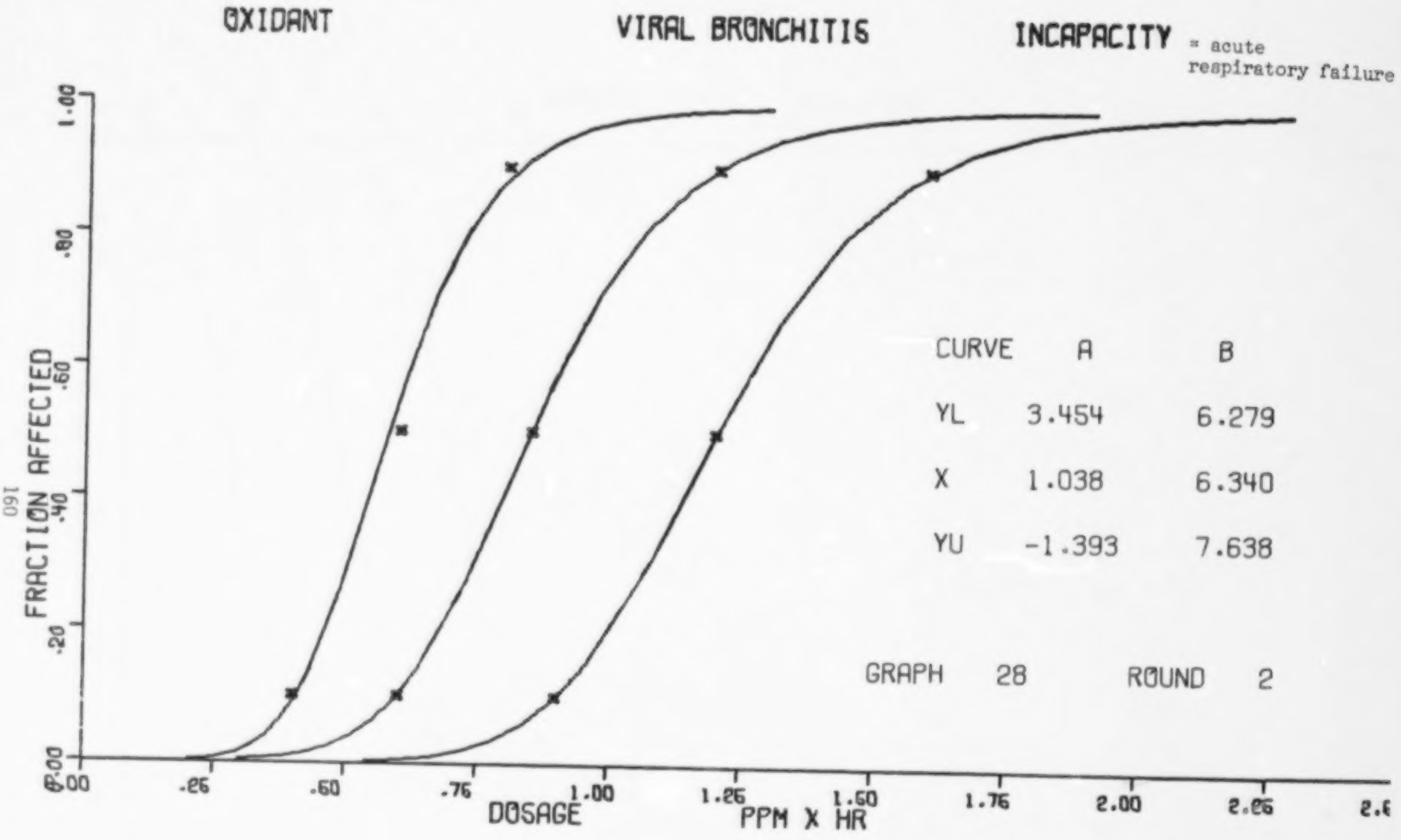




CURVE	A	B
YL	3.958	3.911
X	3.454	6.279
YU	.911	7.595

GRAPH 26 ROUND 2

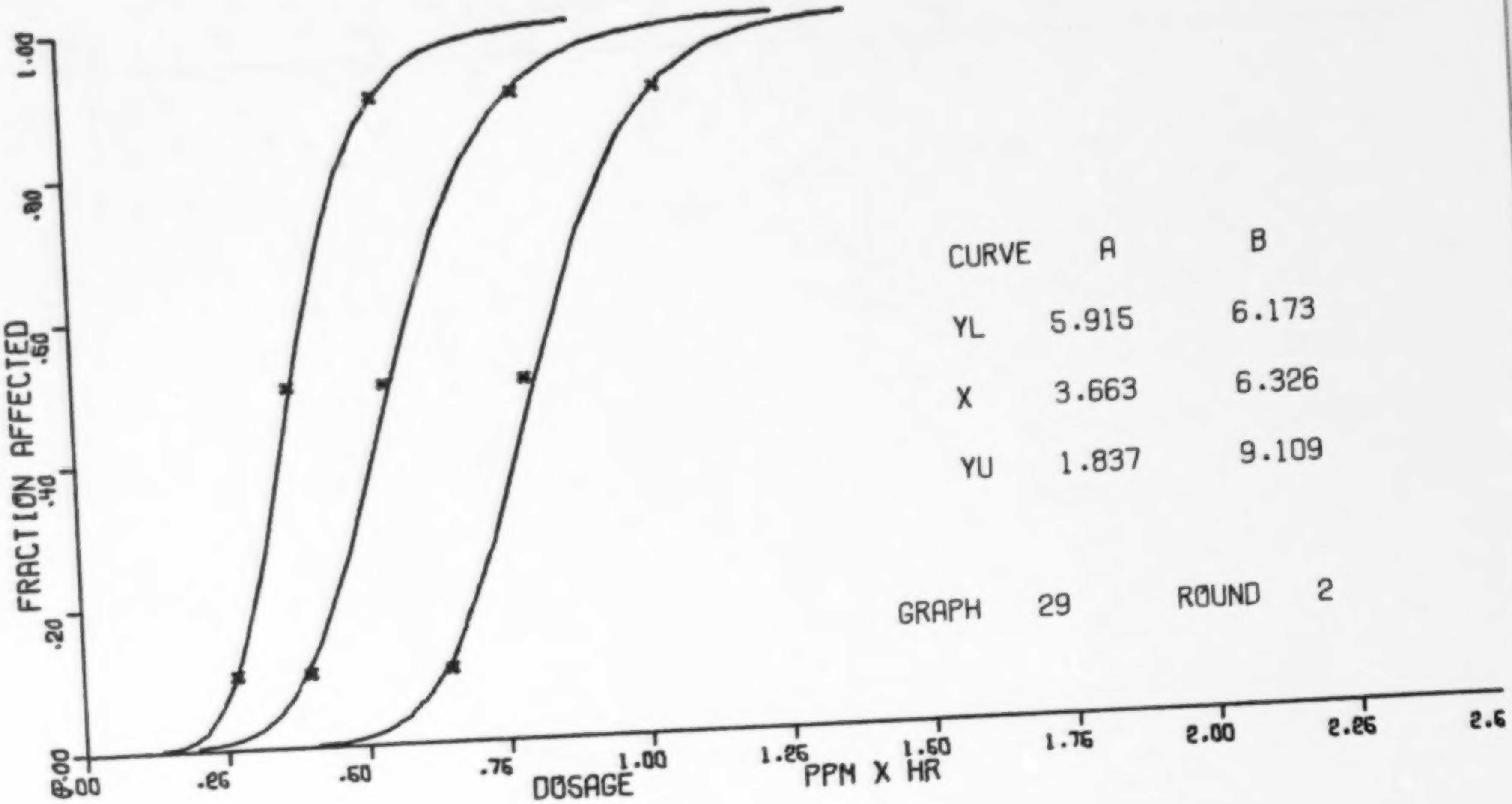

OXIDANT
ASTHMA
DISCOMFORT = dyspnea
FRACTION AFFECTED
1.00
.80
.60
.40
.20
0.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 5.441 3.385
X 5.507 6.279
YU 4.374 9.196
GRAPH 27
ROUND 2


OXIDANT
VIRAL BRONCHITIS
INCAPACITY = acute respiratory failure
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
2.
DOSAGE
PPM X HR
CURVE A B
YL 3.454 6.279
X 1.038 6.340
YU -1.393 7.638
GRAPH 28
ROUND 2

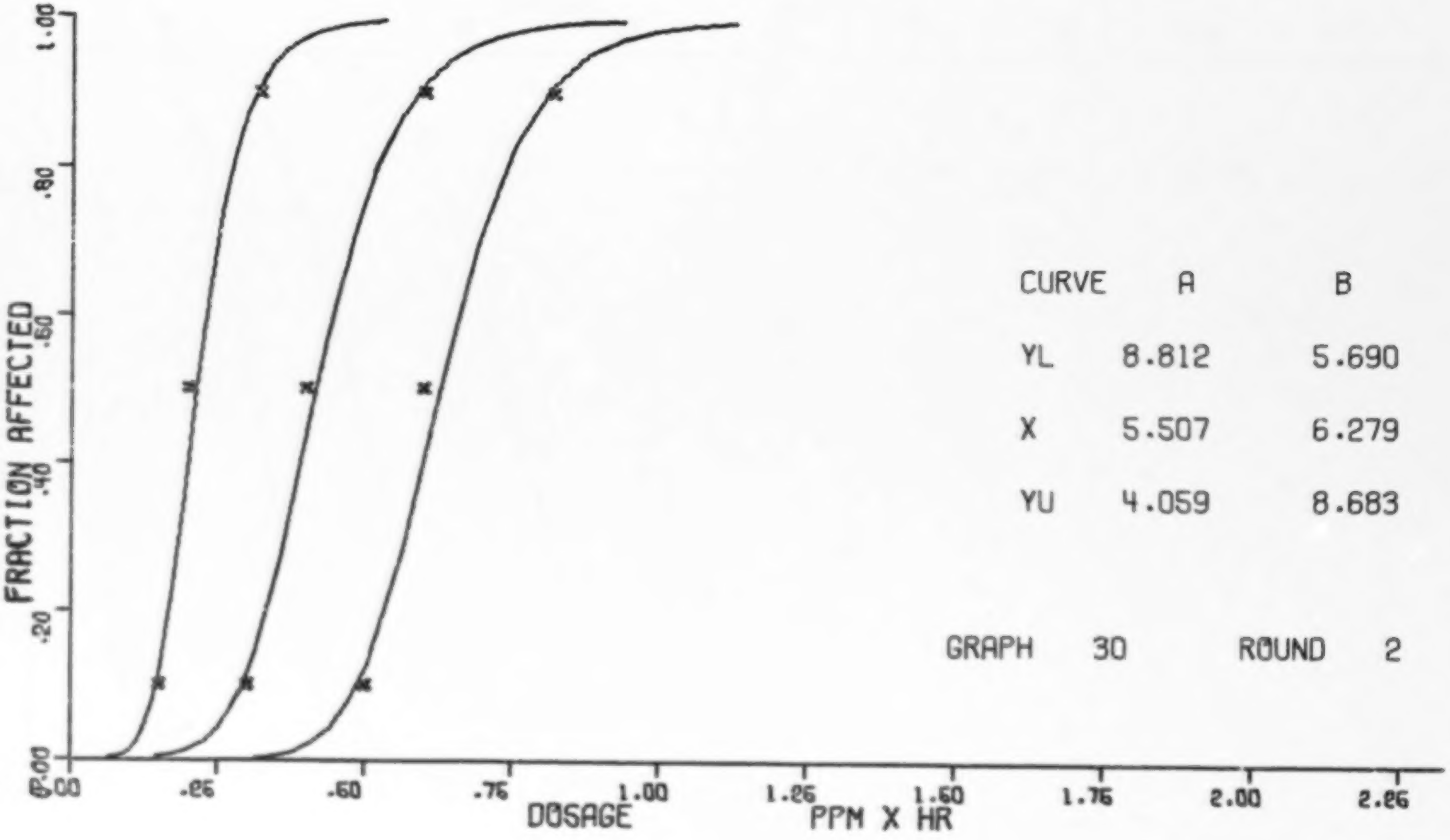
OXIDANT

VIRAL BRONCHITIS

DISABILITY = onset or worsening of dyspnea

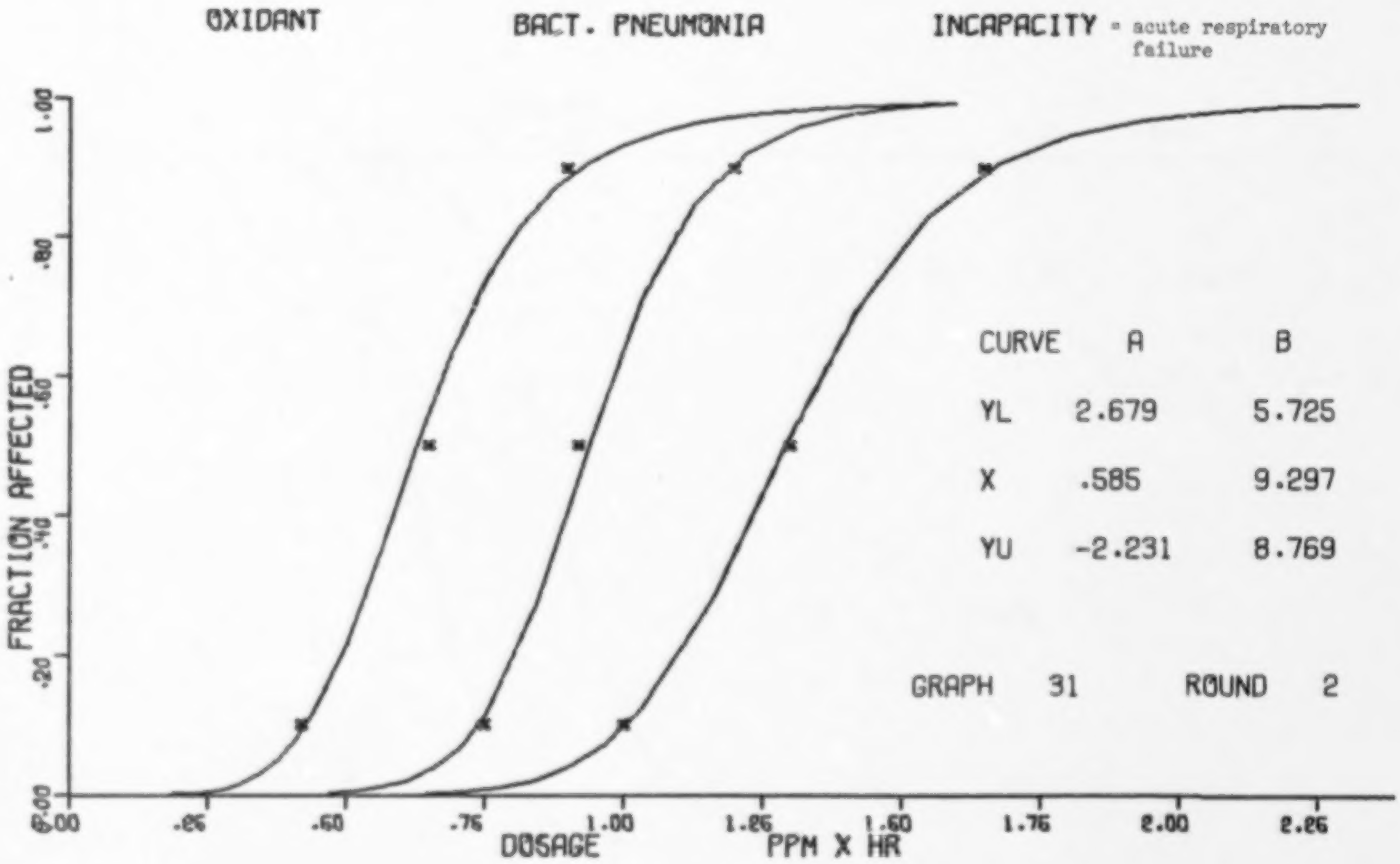


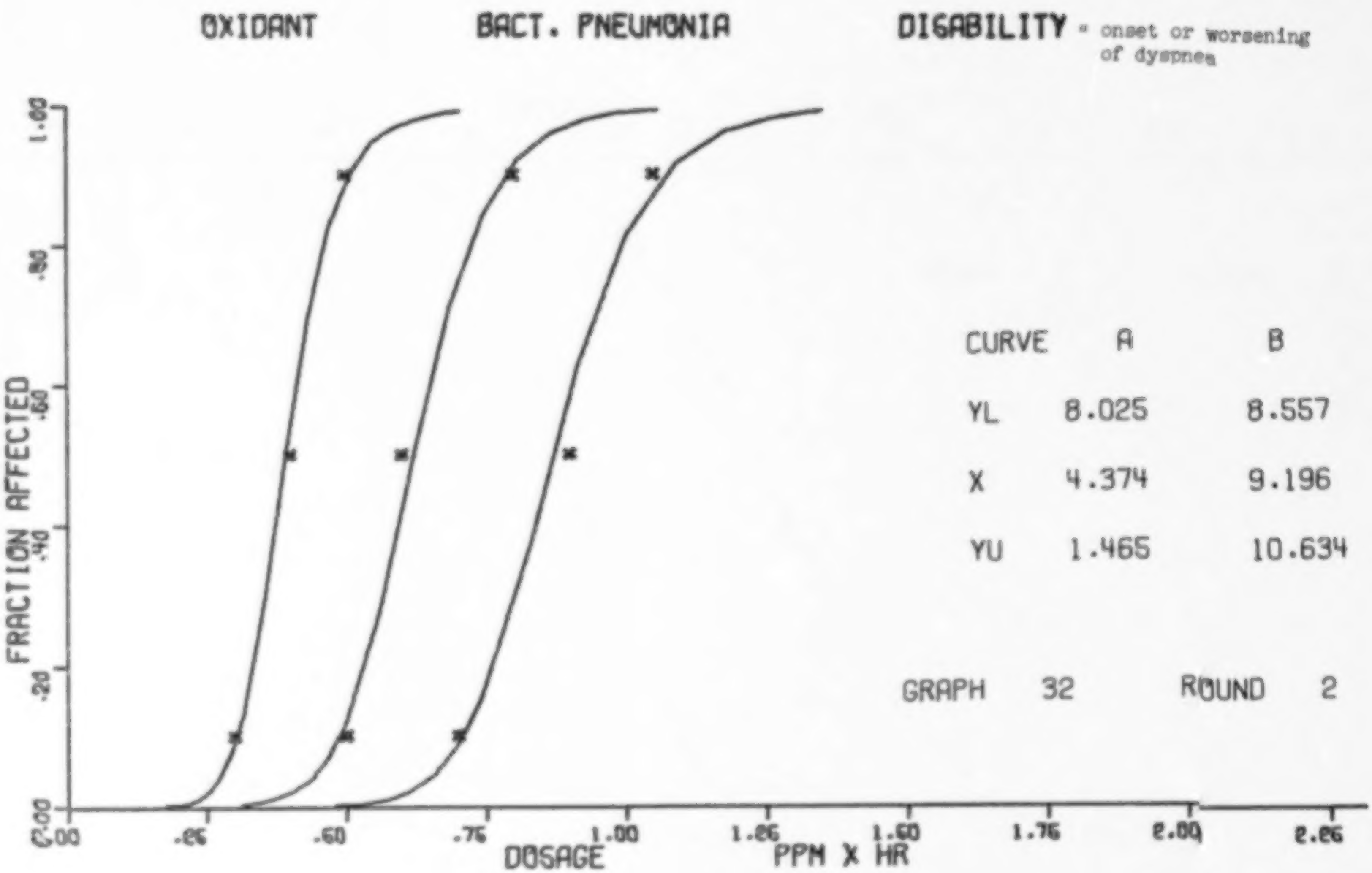
OXIDANT VIRAL BRONCHITIS DISCOMFORT = worsening of cough



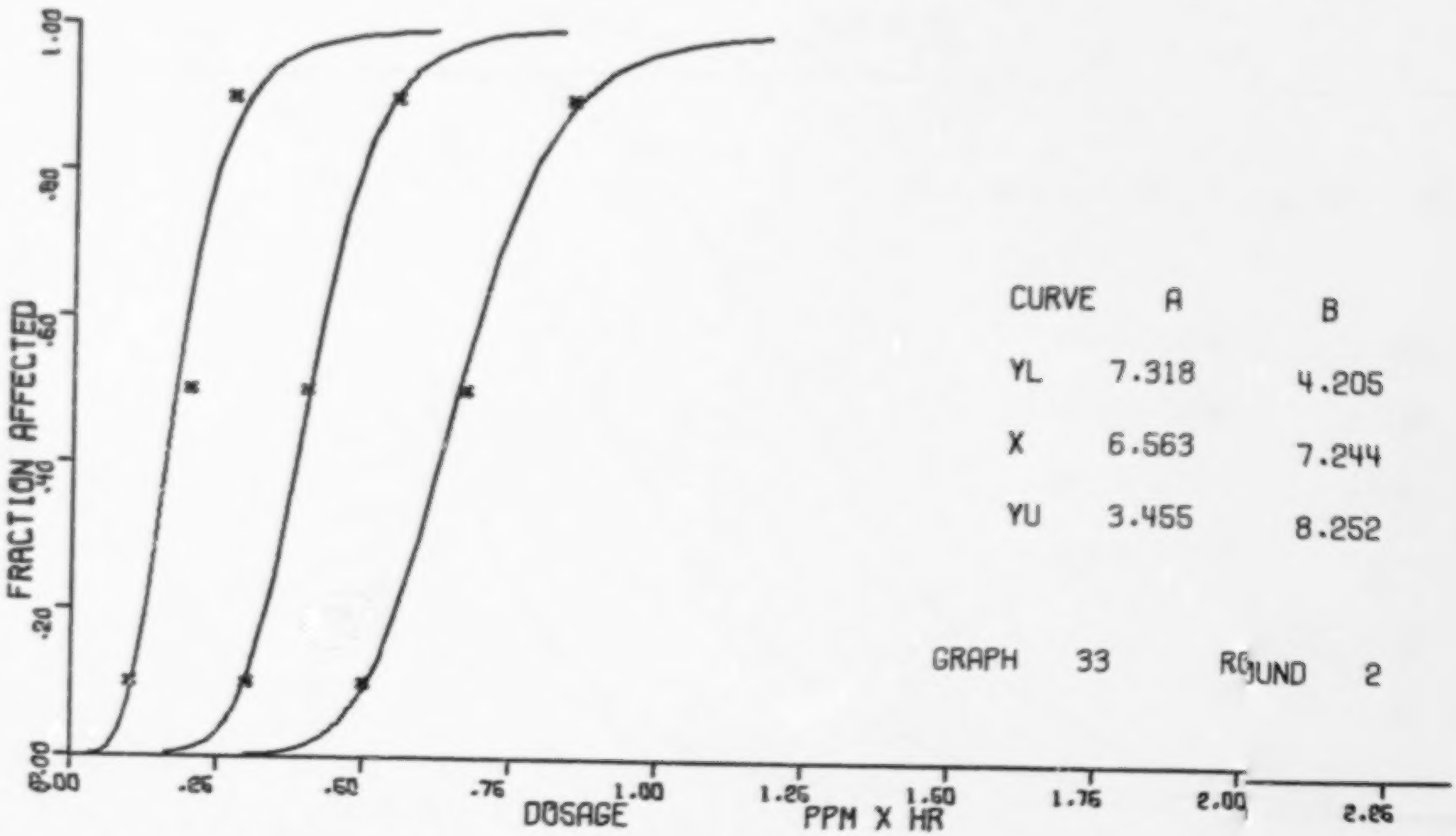
CURVE	A	B
YL	8.812	5.690
X	5.507	6.279
YU	4.059	8.683

GRAPH 30 ROUND 2


OXIDANT
BACT. PNEUMONIA
INCAPACITY = acute respiratory failure
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 2.679 5.725
X .585 9.297
YU -2.231 8.769
GRAPH 31
ROUND 2

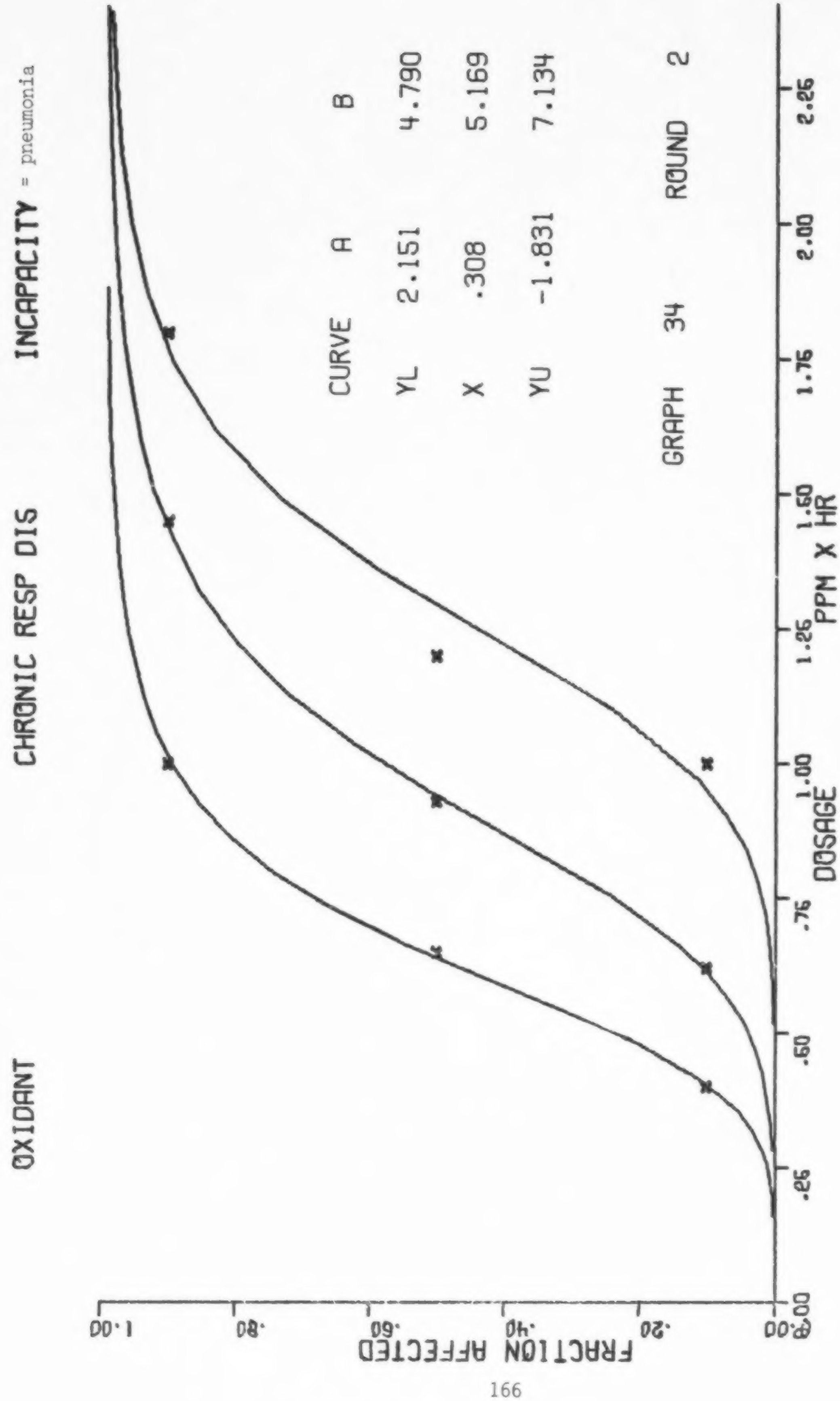

OXIDANT
BACT. PNEUMONIA
DISABILITY = onset or worsening of dyspnea
CURVE A B
YL 8.025 8.557
X 4.374 9.196
YU 1.465 10.634
GRAPH 32
ROUND 2
FRACTION AFFECTED
.00
.20
.40
.60
.80
1.00
.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR

OXIDANT BACT. PNEUMONIA DISCOMFORT = worsening of cough

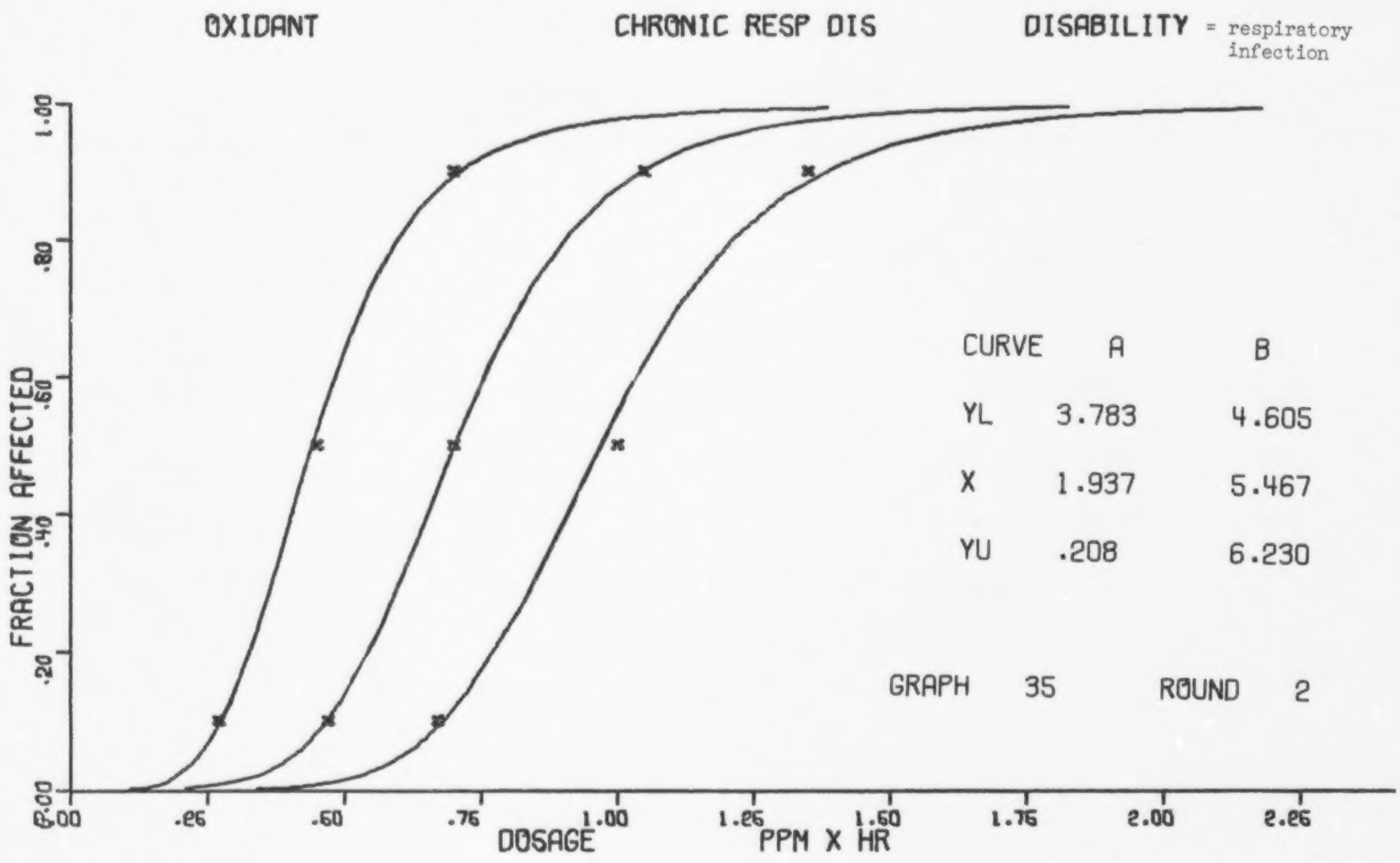


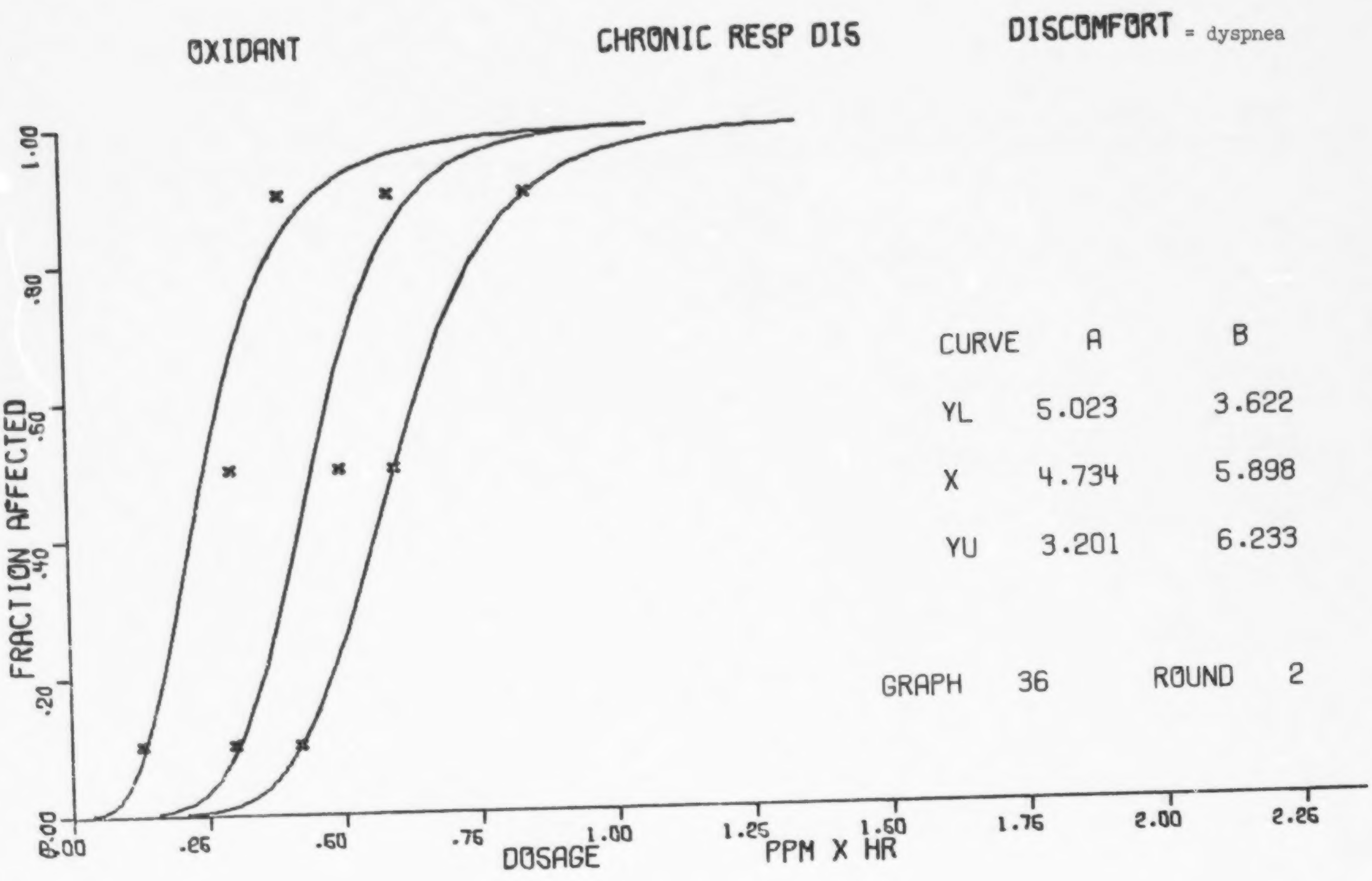
CURVE	A	B
YL	7.318	4.205
X	6.563	7.244
YU	3.455	8.252

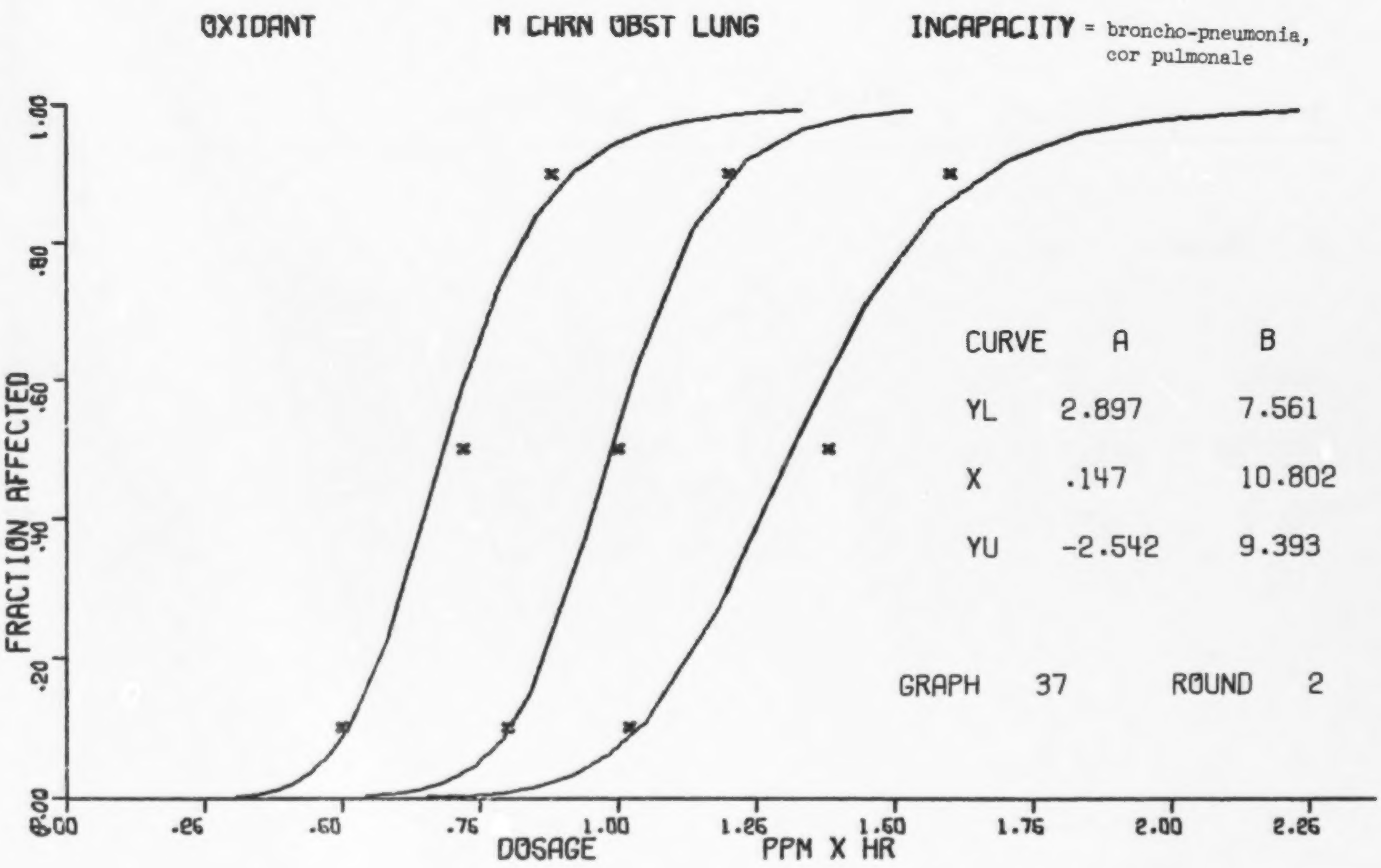
GRAPH 33 ROUND 2

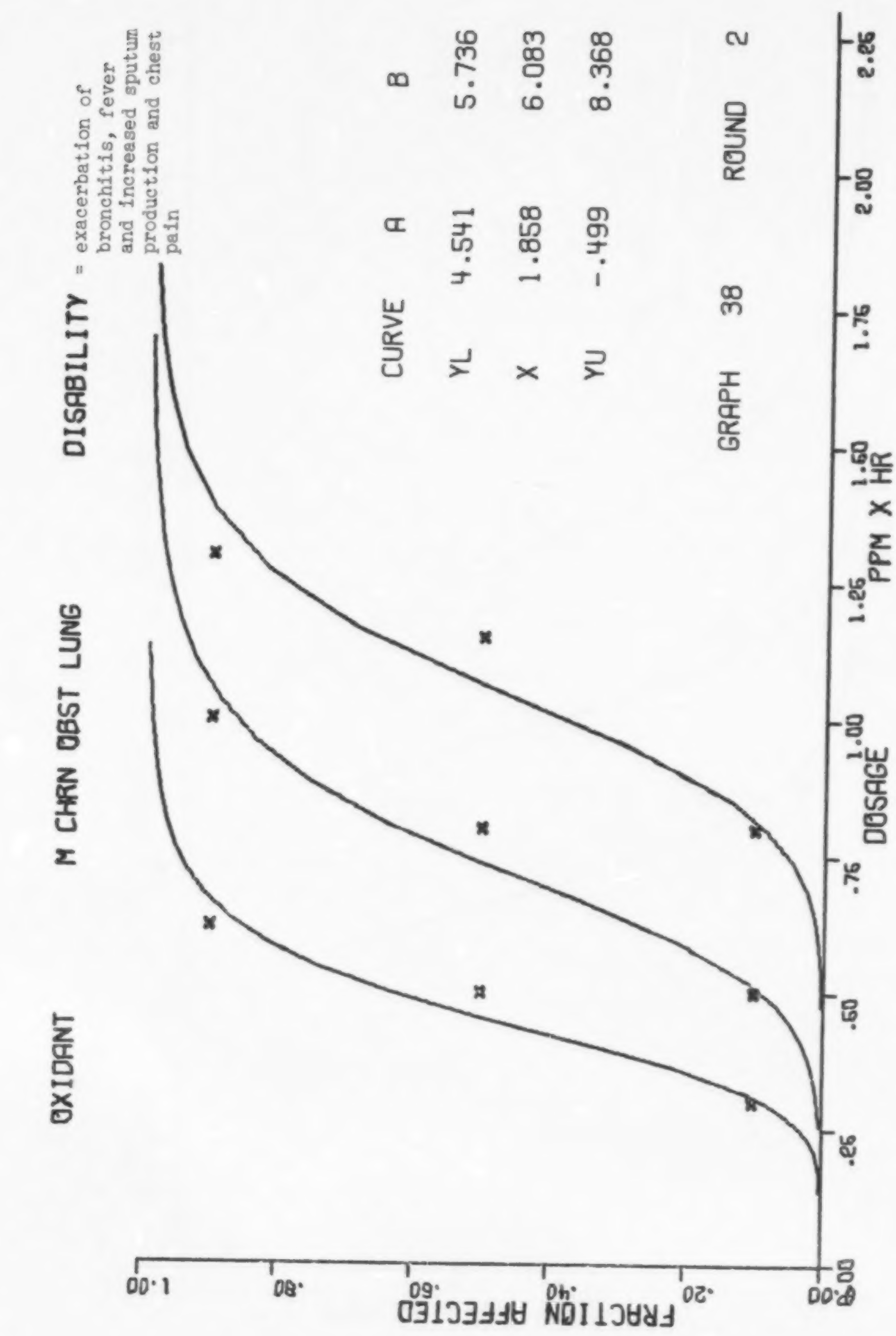


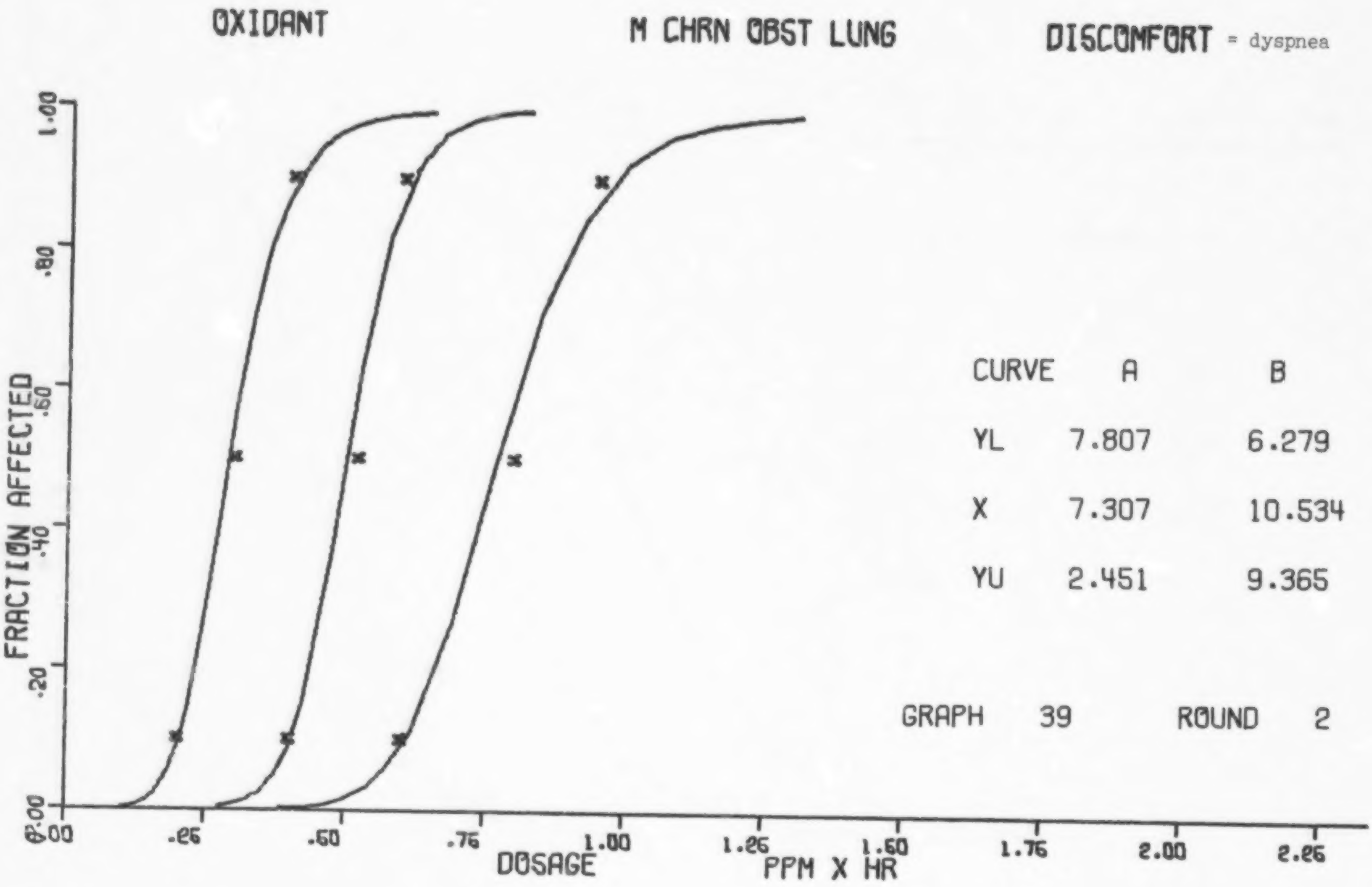
OXIDANT CHRONIC RESP DIS INCAPACITY = pneumonia


OXIDANT
CHRONIC RESP DIS
DISABILITY = respiratory infection
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 3.783 4.605
X 1.937 5.467
YU .208 6.230
GRAPH 35
ROUND 2

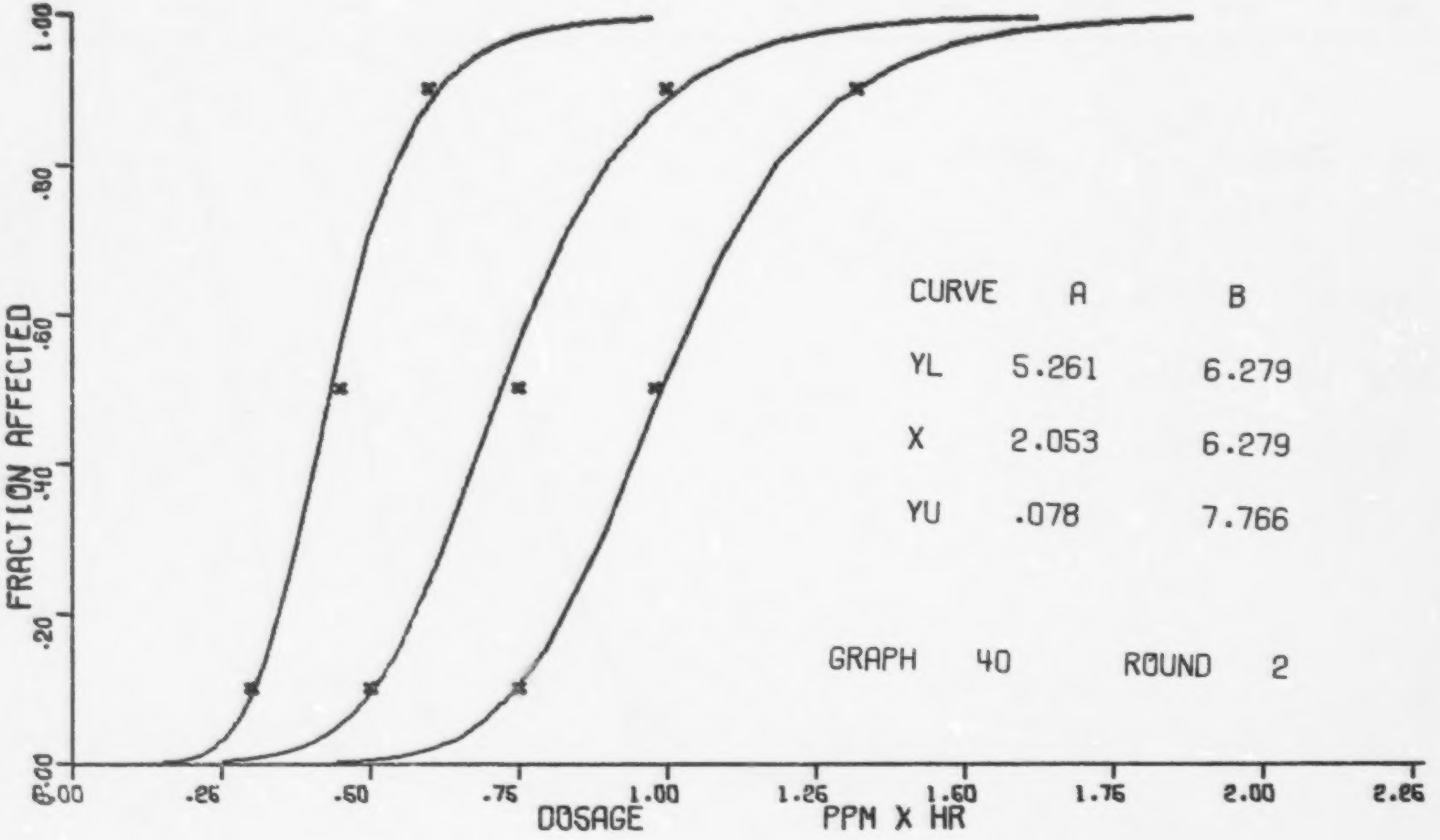

OXIDANT
CHRONIC RESP DIS
DISCOMFORT = dyspnea
CURVE A B
YL 5.023 3.622
X 4.734 5.898
YU 3.201 6.233
GRAPH 36
ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR

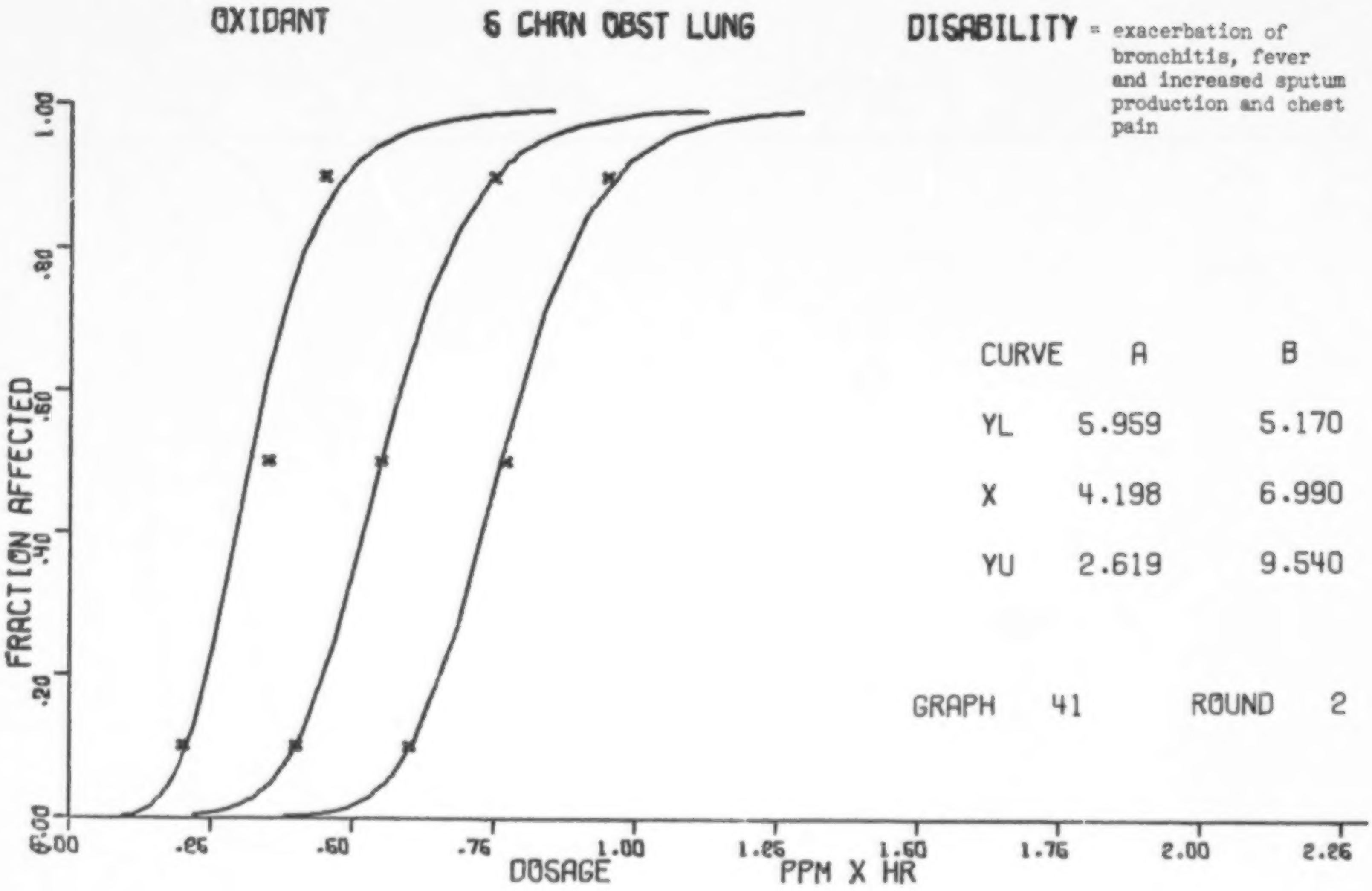

OXIDANT
M CHRN OBST LUNG
INCAPACITY = broncho-pneumonia, cor pulmonale
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 2.897 7.561
X .147 10.802
YU -2.542 9.393
GRAPH 37
ROUND 2

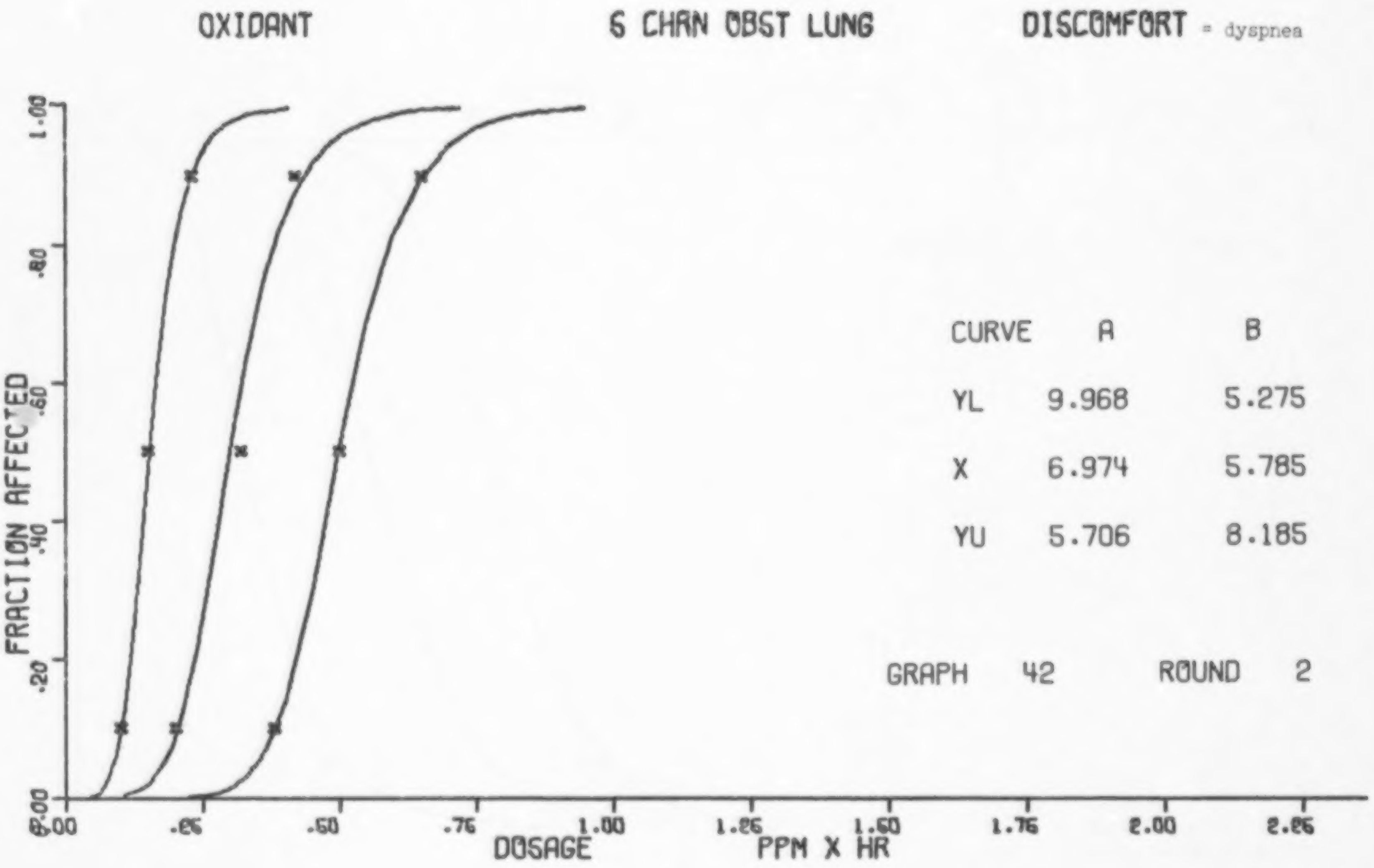

OXIDANT
M CHRN OBST LUNG
DISABILITY = exacerbation of bronchitis, fever and increased sputum production and chest pain
CURVE A B
YL 4.541 5.736
X 1.858 6.083
YU -.499 8.368
GRAPH 38 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE PPM X HR
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25

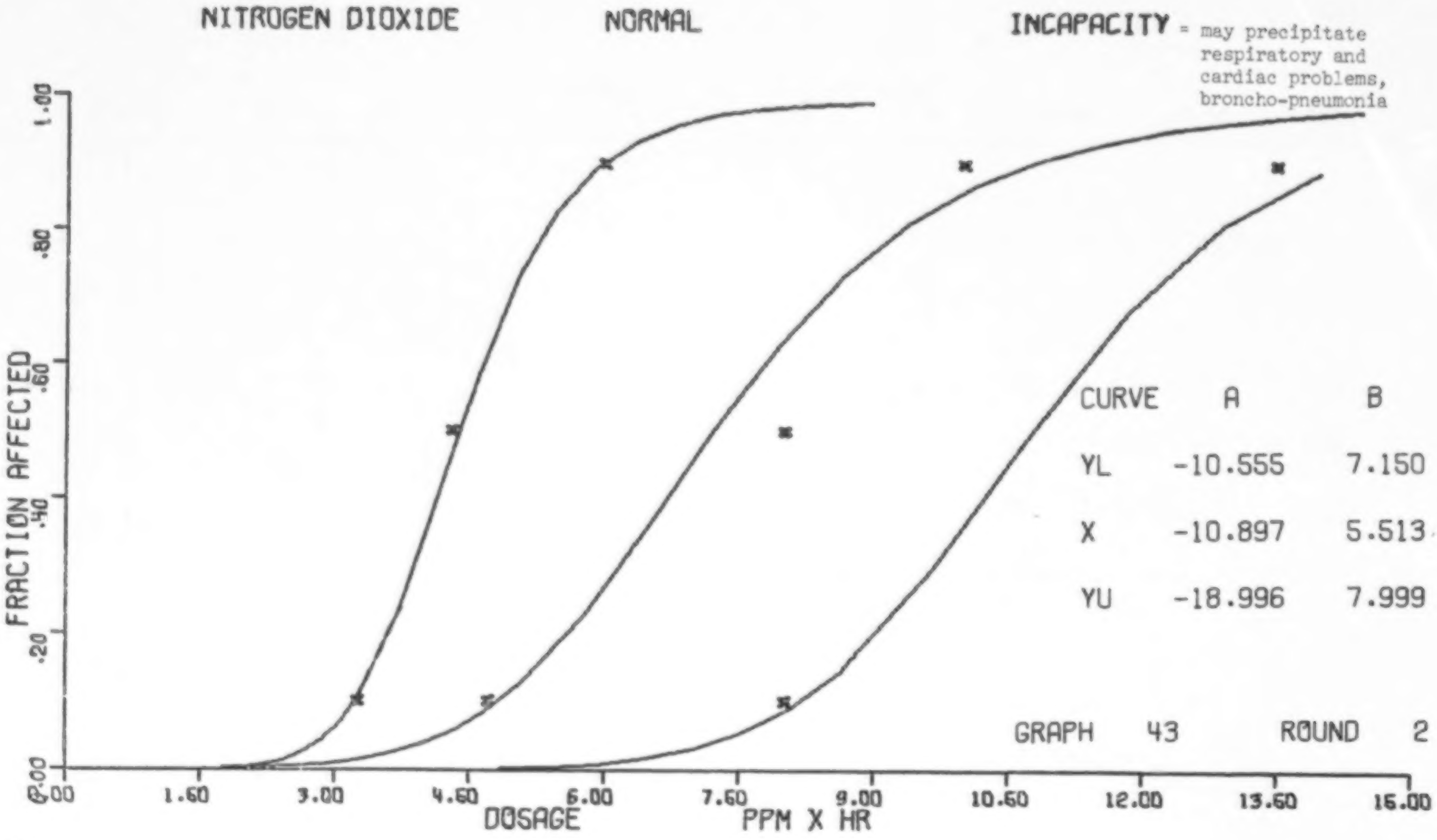

OXIDANT
M CHRN OBST LUNG
DISCOMFORT = dyspnea
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 7.807 6.279
X 7.307 10.534
YU 2.451 9.365
GRAPH 39
ROUND 2

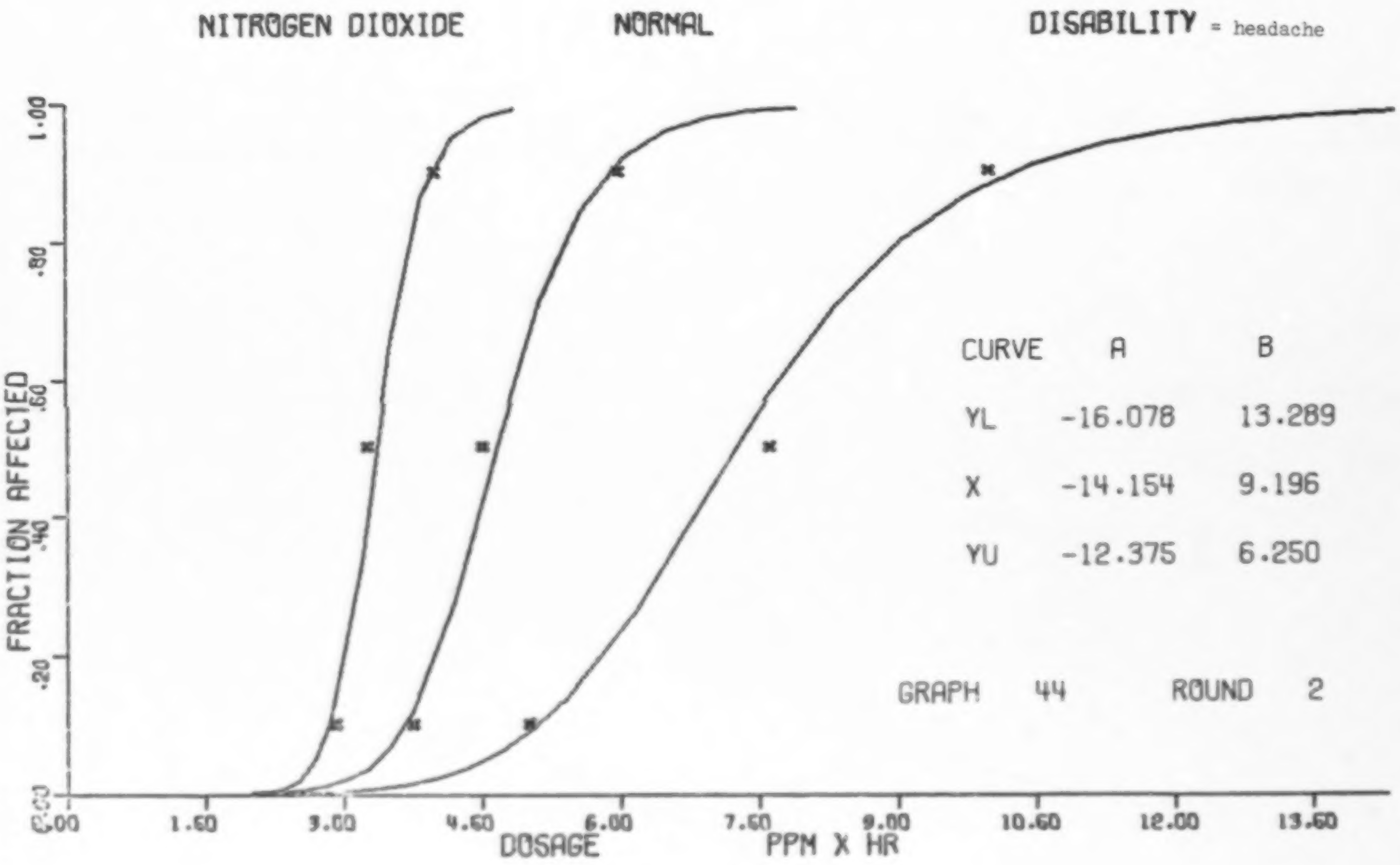
OXIDANT 5 CHRN OBST LUNG INCAPACITY = broncho-pneumonia, cor pulmonale

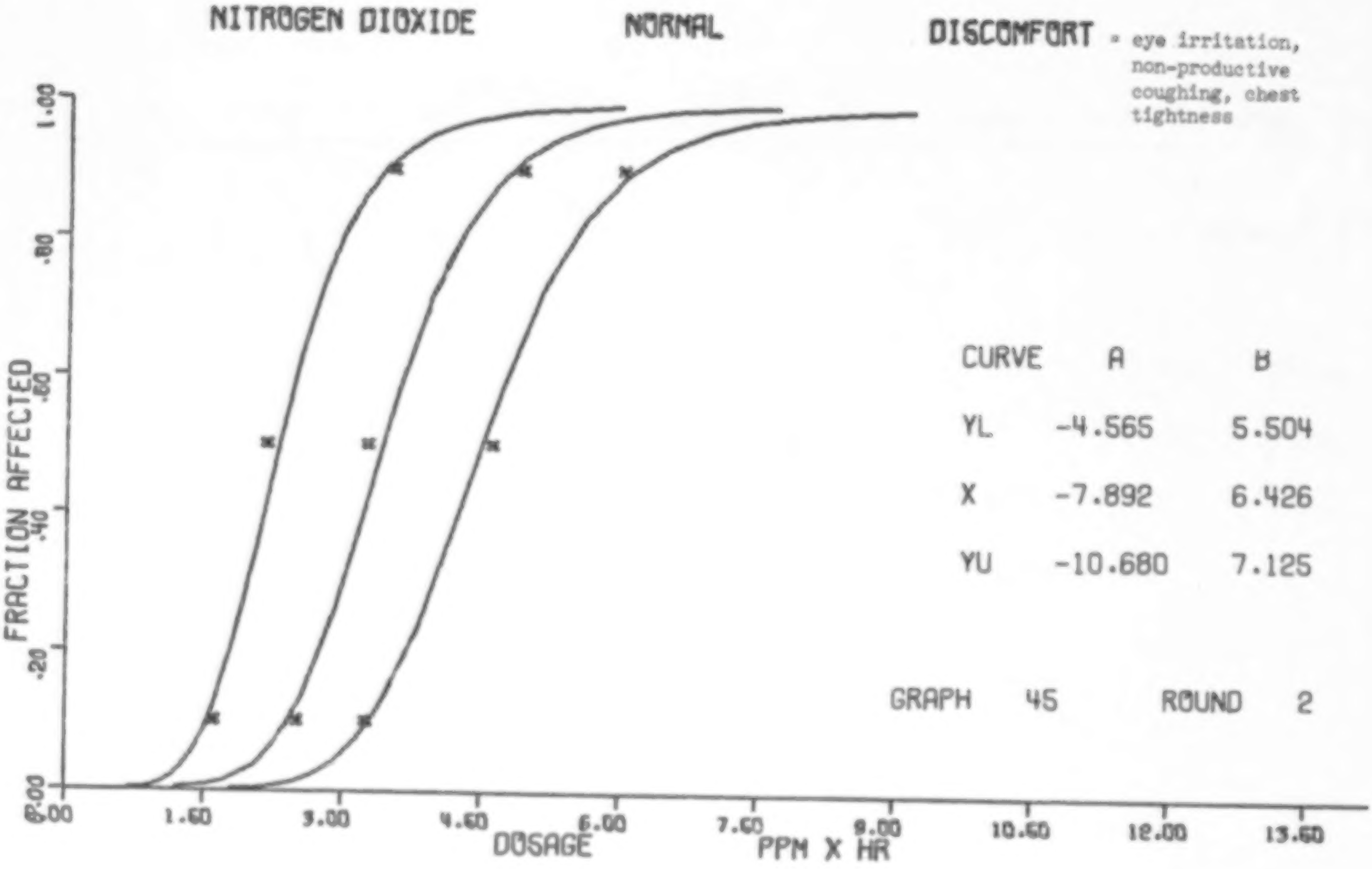


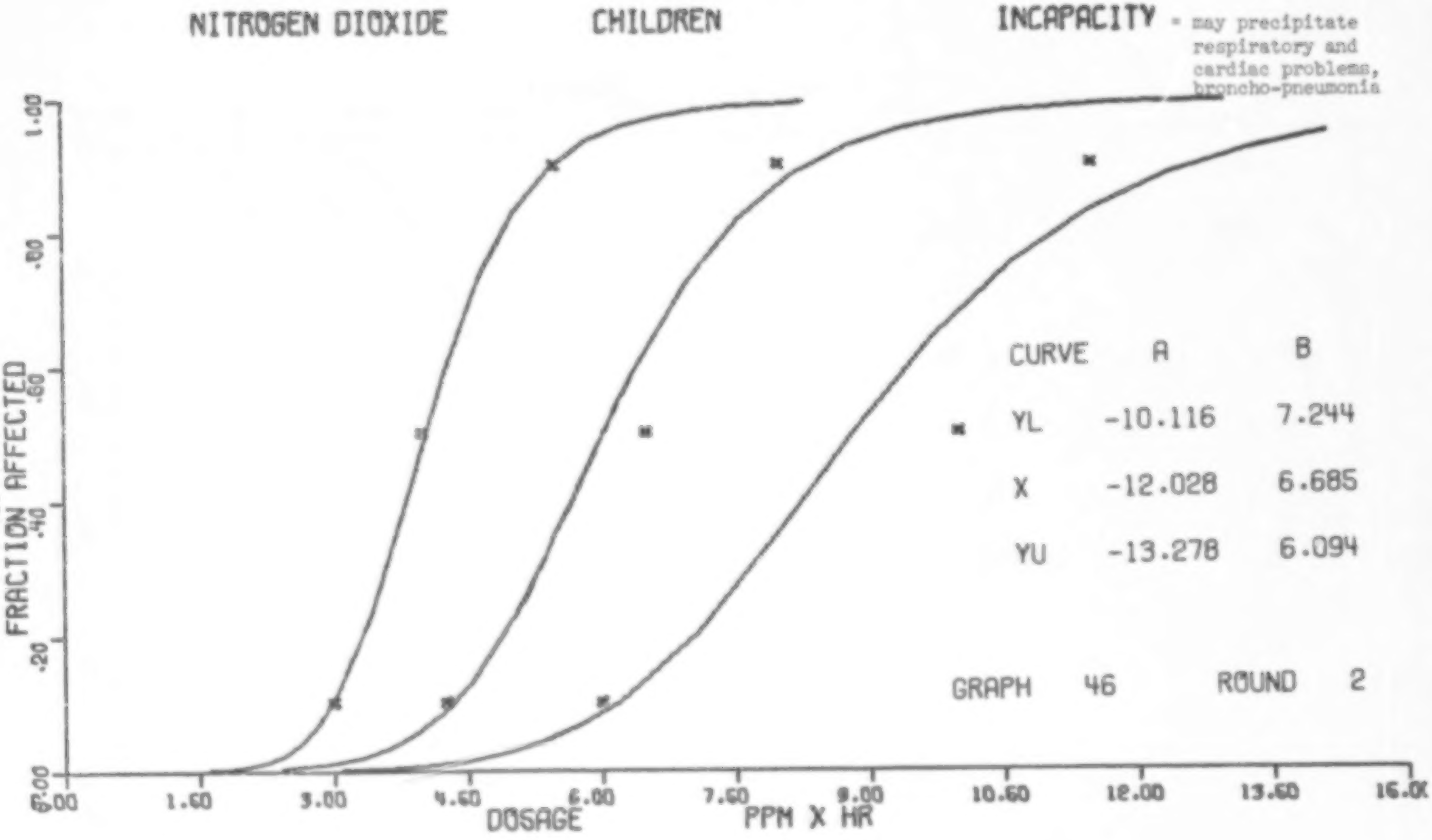

OXIDANT
6 CHRN OBST LUNG
DISABILITY = exacerbation of bronchitis, fever and increased sputum production and chest pain
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 5.959 5.170
X 4.198 6.990
YU 2.619 9.540
GRAPH 41
ROUND 2


OXIDANT
6 CHRN OBST LUNG
DISCOMFORT = dyspnea
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
2.00
2.25
DOSAGE
PPM X HR
CURVE A B
YL 9.968 5.275
X 6.974 5.785
YU 5.706 8.185
GRAPH 42
ROUND 2

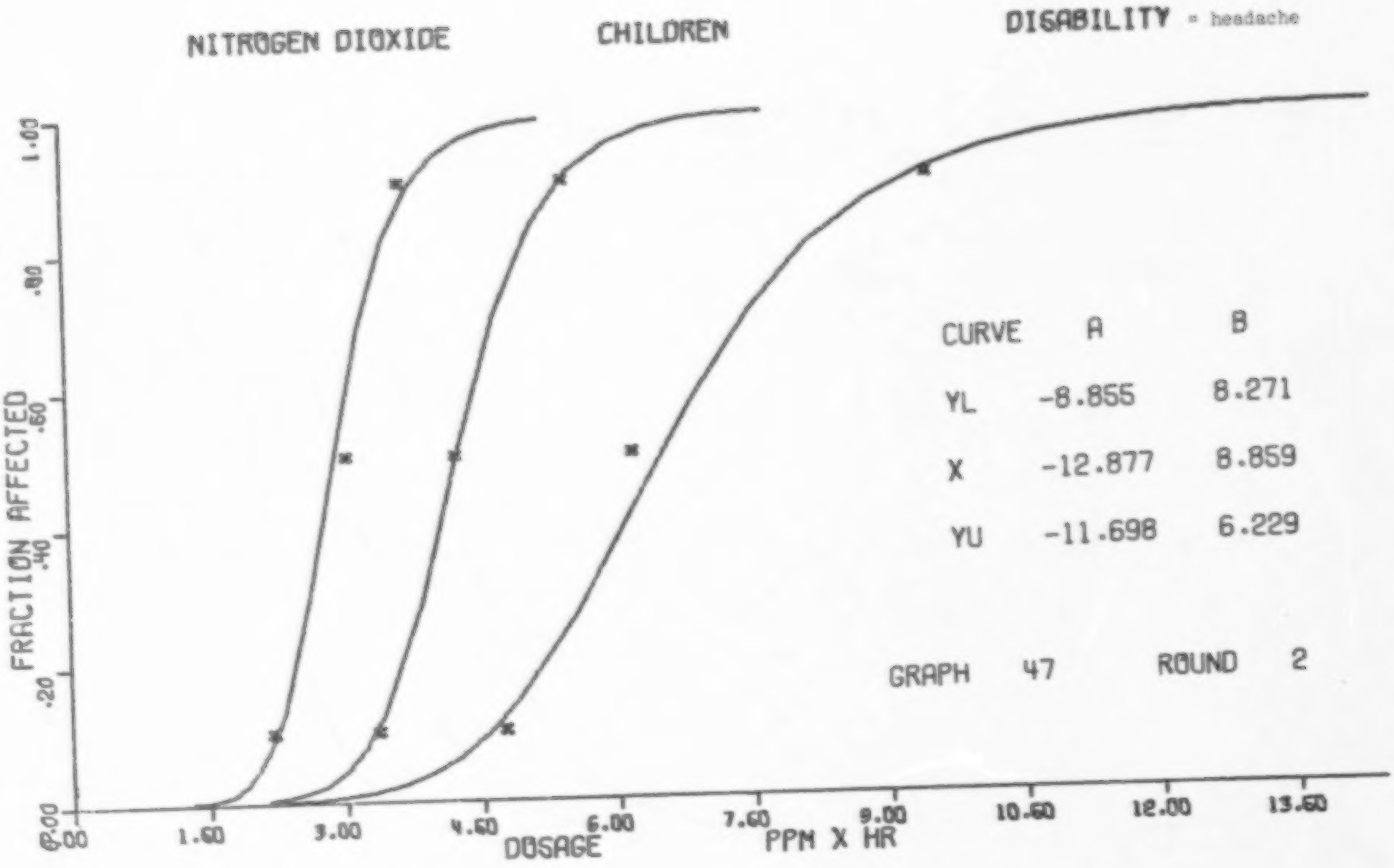

NITROGEN DIOXIDE
NORMAL
INCAPACITY = may precipitate respiratory and cardiac problems, broncho-pneumonia
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.60
3.00
4.60
6.00
7.60
9.00
10.60
12.00
13.60
16.00
DOSAGE
PPM X HR
CURVE A B
YL -10.555 7.150
X -10.897 5.513
YU -18.996 7.999
GRAPH 43
ROUND 2


NITROGEN DIOXIDE
NORMAL
DISABILITY = headache
CURVE A B
YL -16.078 13.289
X -14.154 9.196
YU -12.375 6.250
GRAPH 44 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
13.50
DOSAGE
PPM X HR


NITROGEN DIOXIDE
NORMAL
DISCOMFORT = eye irritation, non-productive coughing, chest tightness
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.60
3.00
4.60
6.00
7.60
9.00
10.60
12.00
13.60
DOSAGE
PPM X HR
CURVE A B
YL -4.565 5.504
X -7.892 6.426
YU -10.680 7.125
GRAPH 45
ROUND 2



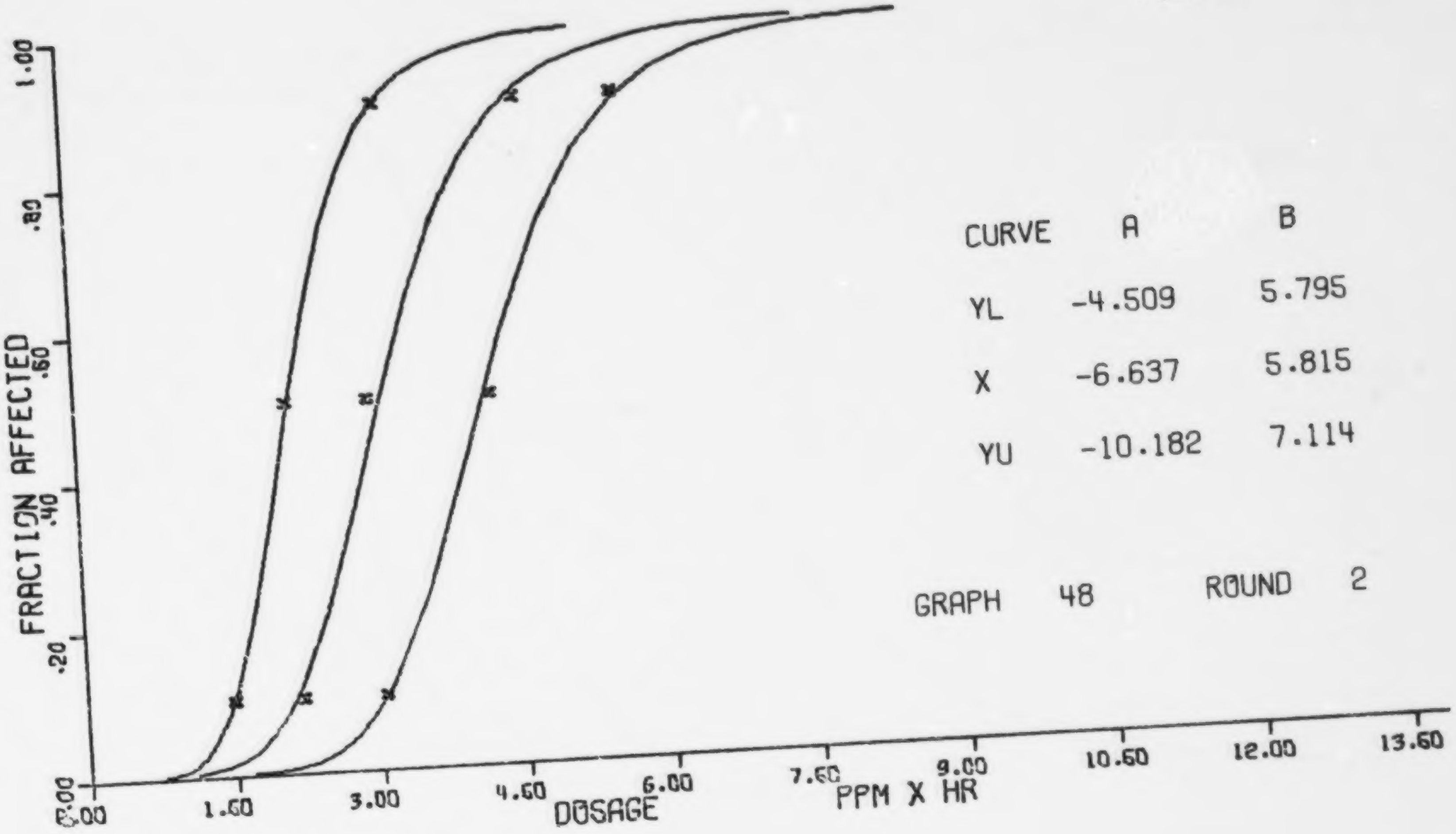
- may precipitate respiratory and cardiac problems, broncho-pneumonia



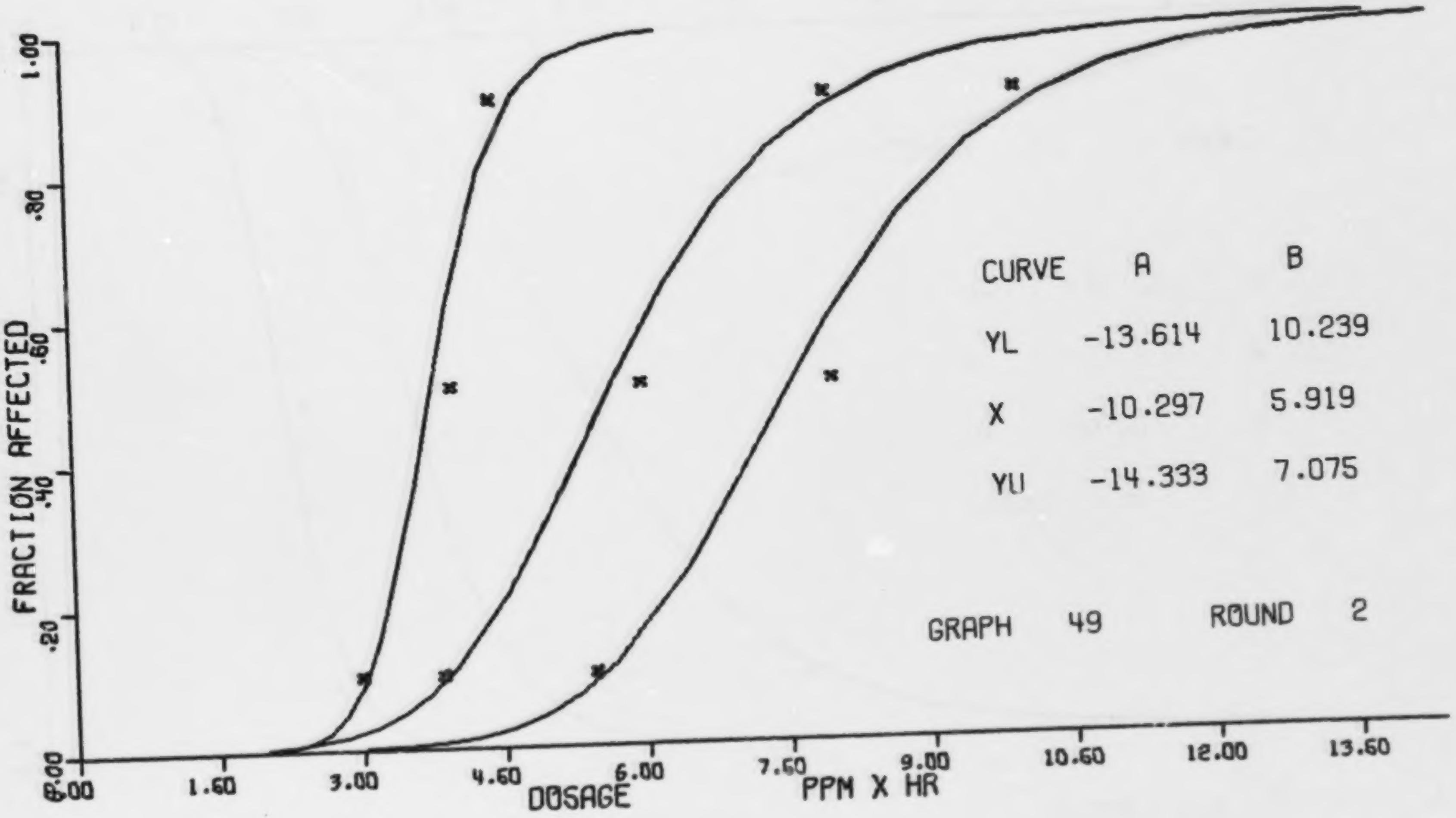
CURVE	A	B
YL	-8.855	8.271
X	-12.877	8.859
YU	-11.698	6.229

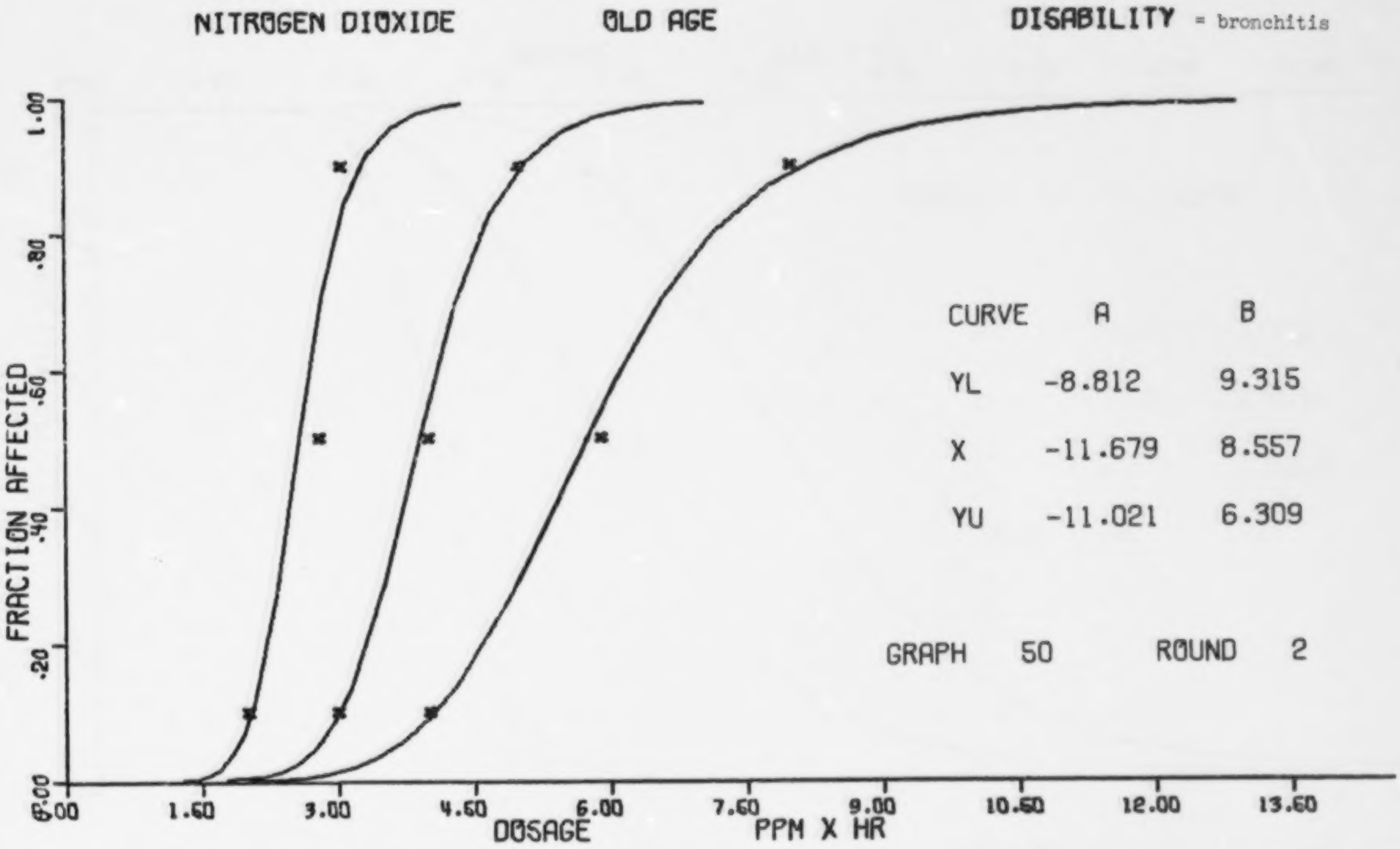
GRAPH 47 ROUND 2

NITROGEN DIOXIDE CHILDREN **DISCOMFORT** = eye irritation, non-productive coughing, chest tightness

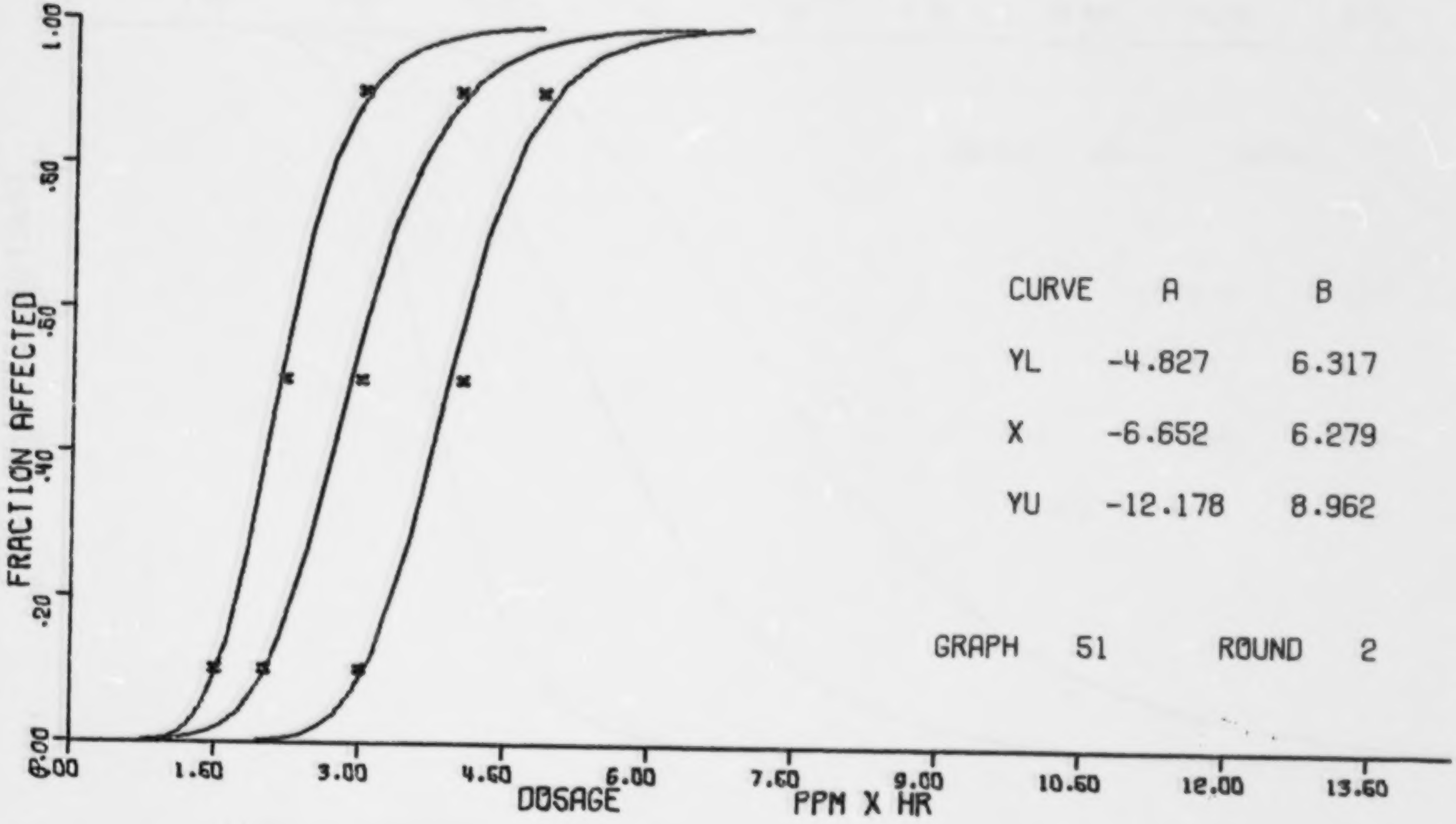


NITROGEN DIOXIDE OLD AGE **INCAPACITY** = acute respiratory failure




NITROGEN DIOXIDE
OLD AGE
DISABILITY = bronchitis
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.60
3.00
4.60
6.00
7.60
9.00
10.60
12.00
13.60
DOSAGE
PPM X HR
CURVE A B
YL -8.812 9.315
X -11.679 8.557
YU -11.021 6.309
GRAPH 50
ROUND 2

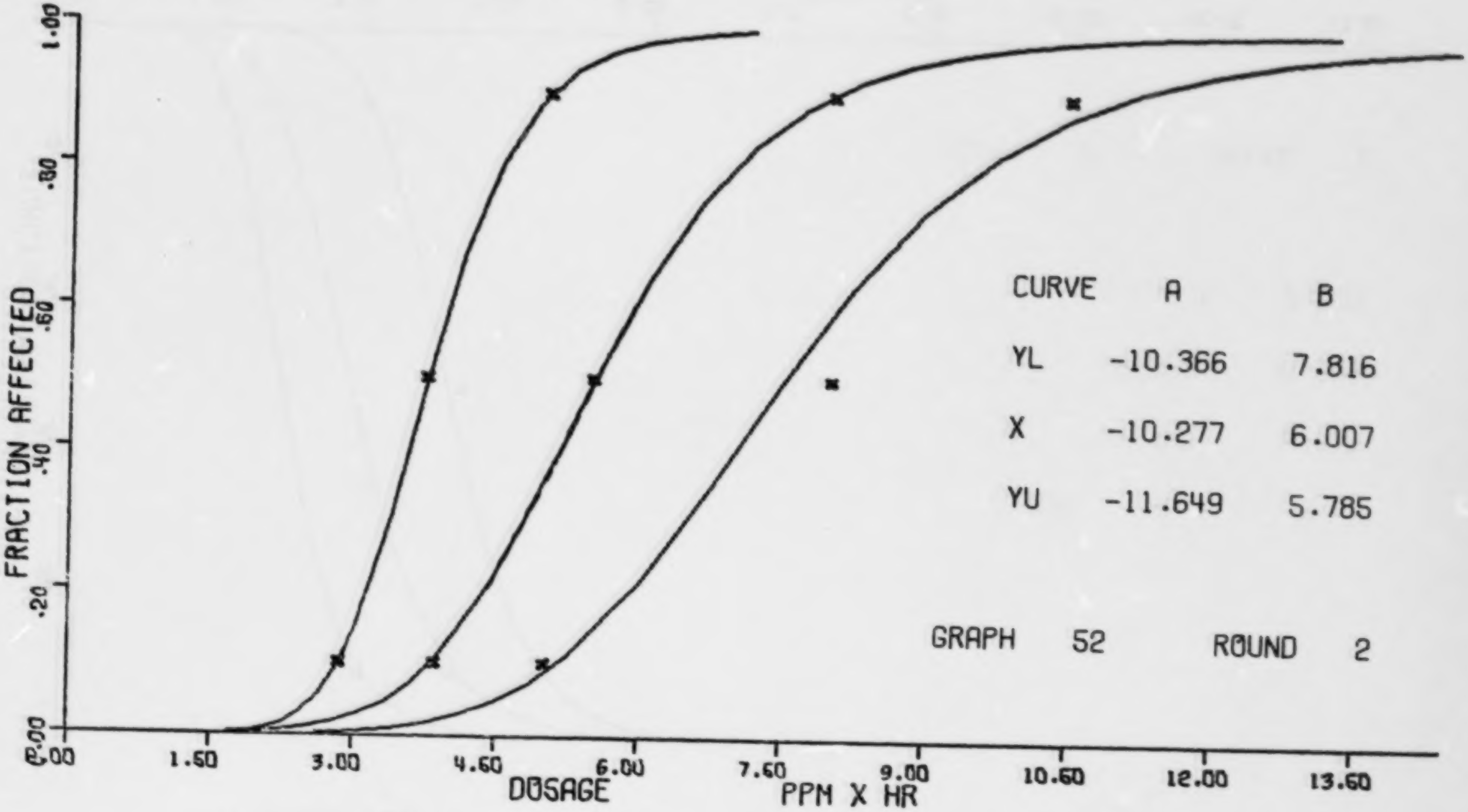
NITROGEN DIOXIDE　　　OLD AGE　　　DISCOMFORT = dyspnea



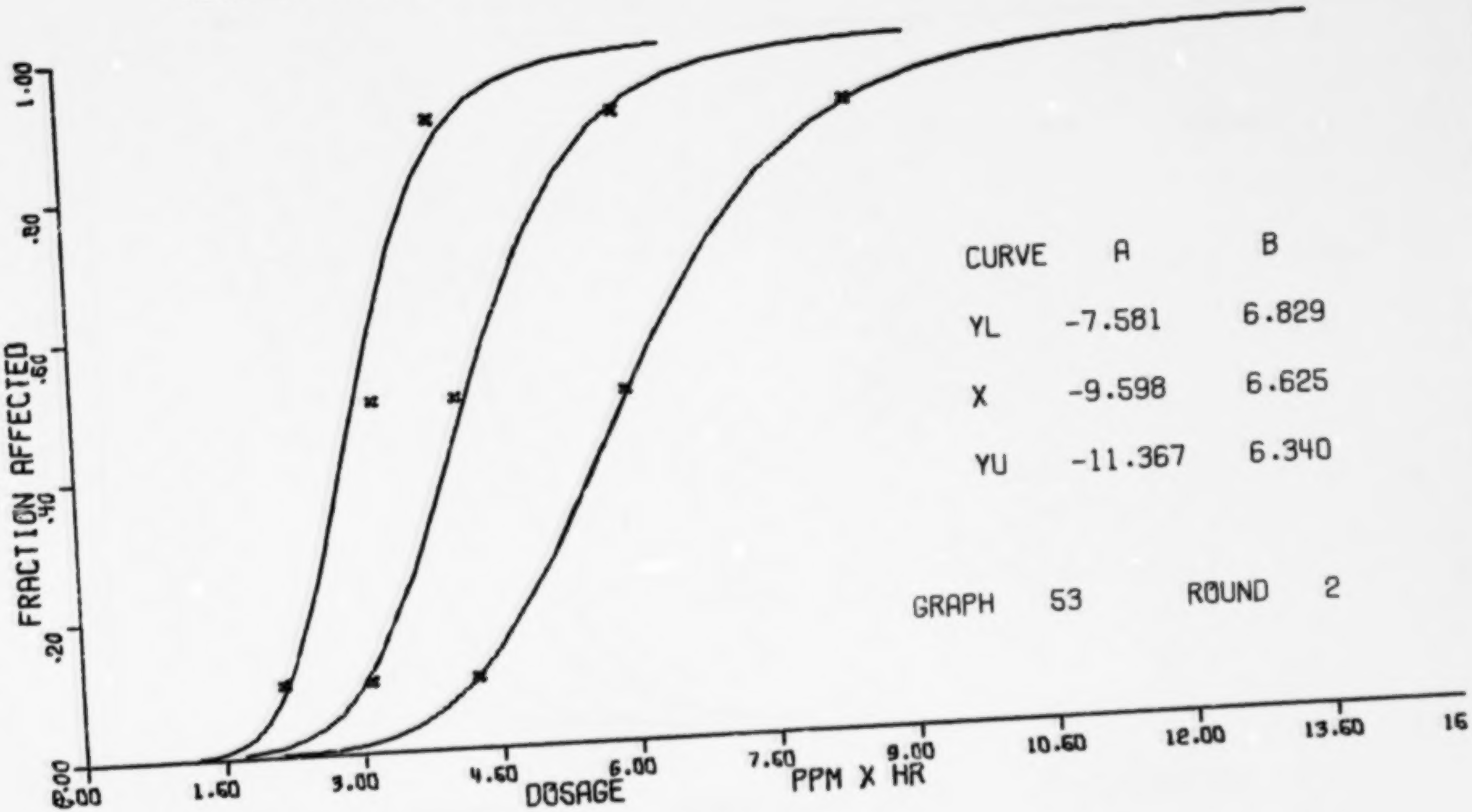
CURVE	A	B
YL	-4.827	6.317
X	-6.652	6.279
YU	-12.178	8.962

GRAPH 51　　ROUND 2

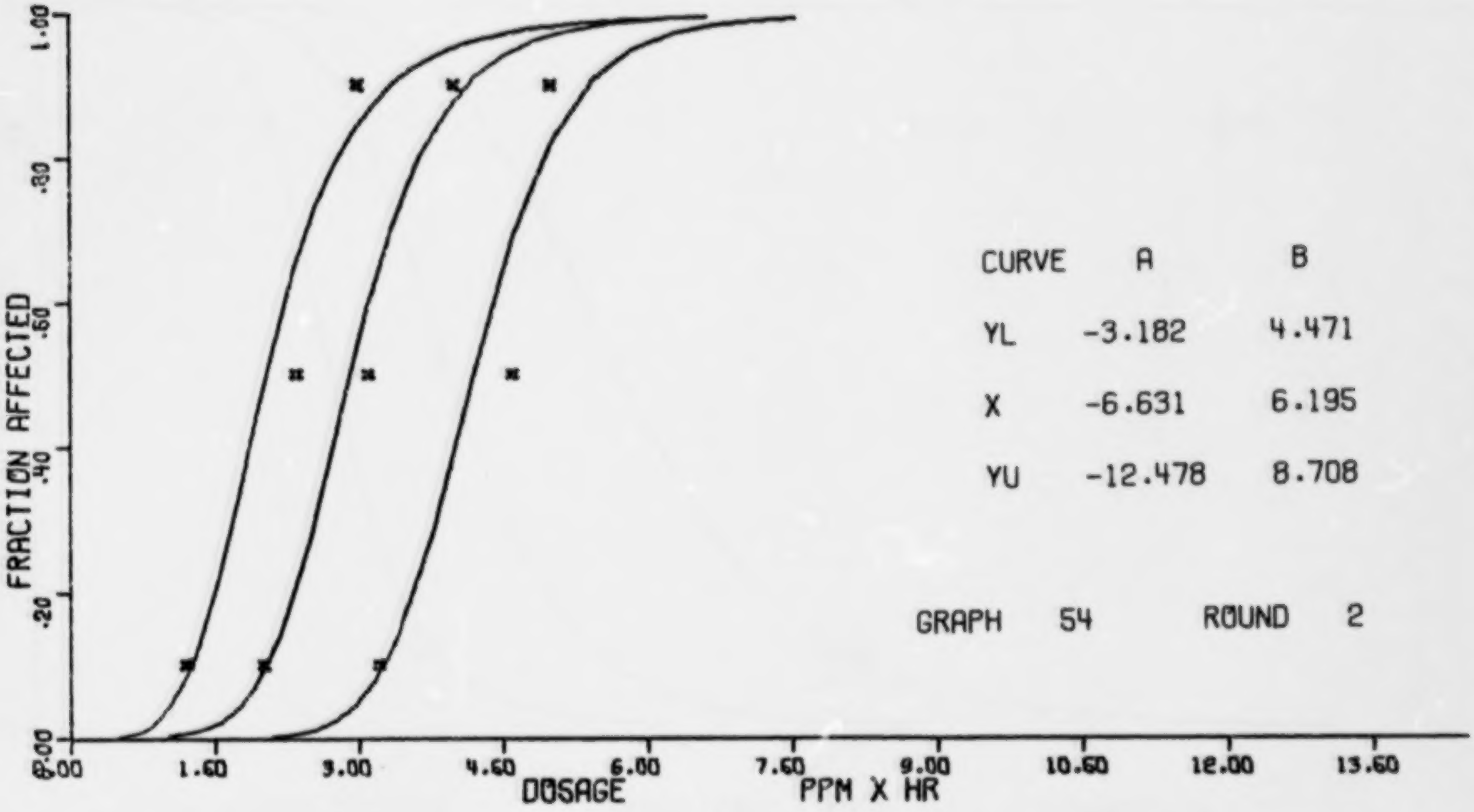
NITROGEN DIOXIDE HEART COND. MILD **INCAPACITY** = pulmonary edema



NITROGEN DIOXIDE HEART COND. MILD **DISABILITY** = congestive heart failure



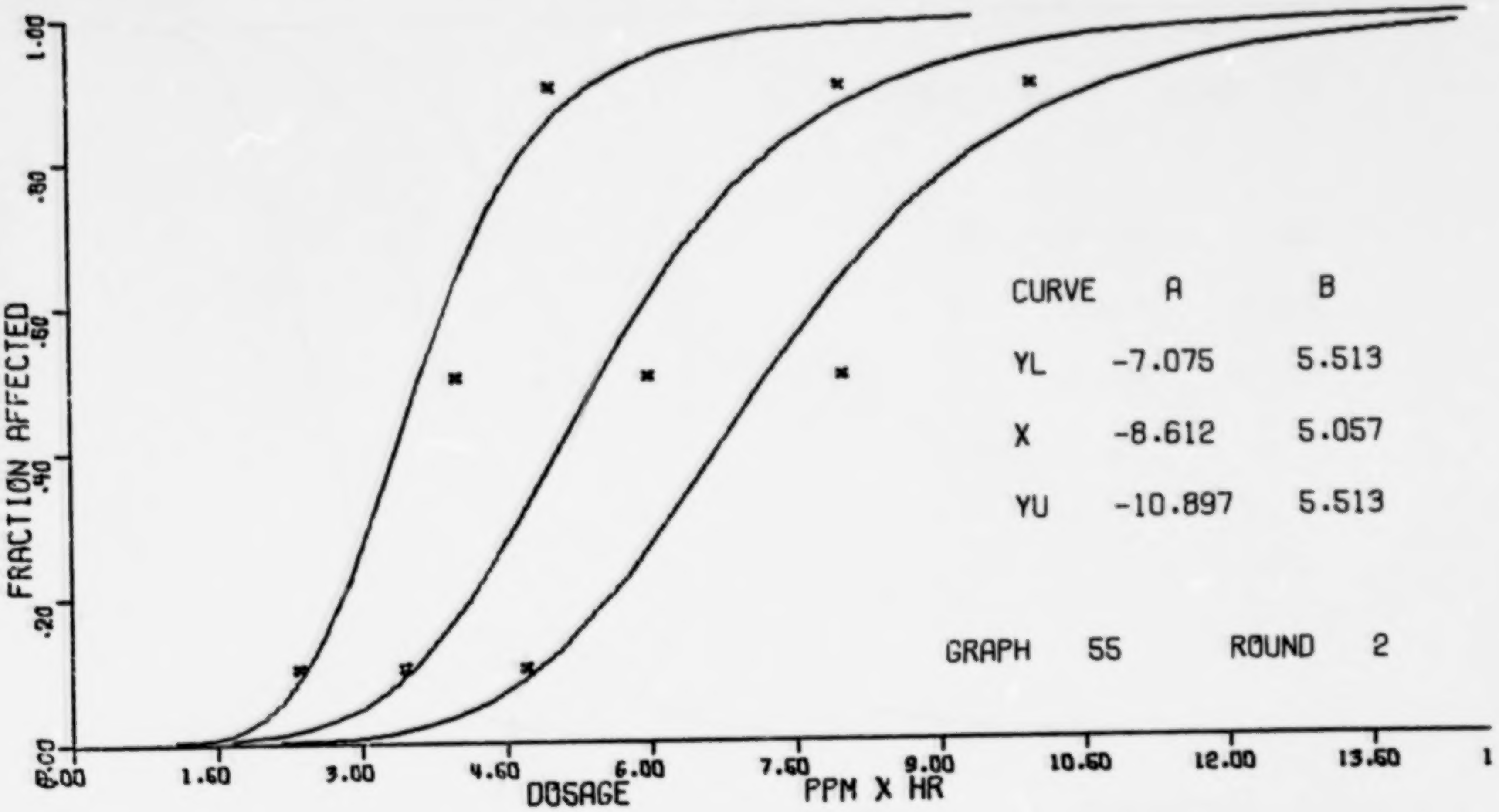
NITROGEN DIOXIDE HEART COND. MILD DISCOMFORT = dyspnea



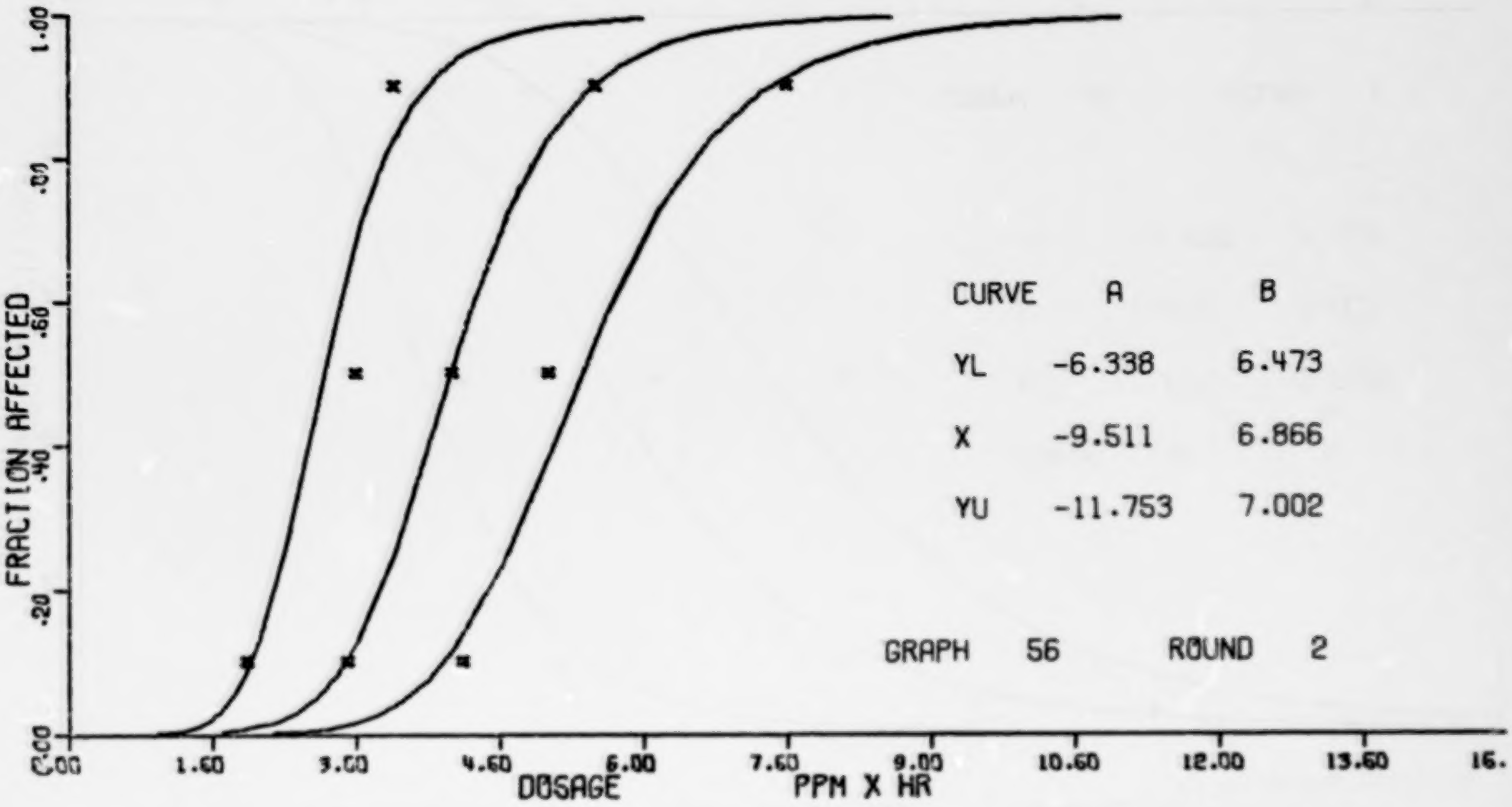
CURVE	A	B
YL	-3.182	4.471
X	-6.631	6.195
YU	-12.478	8.708

GRAPH 54 ROUND 2

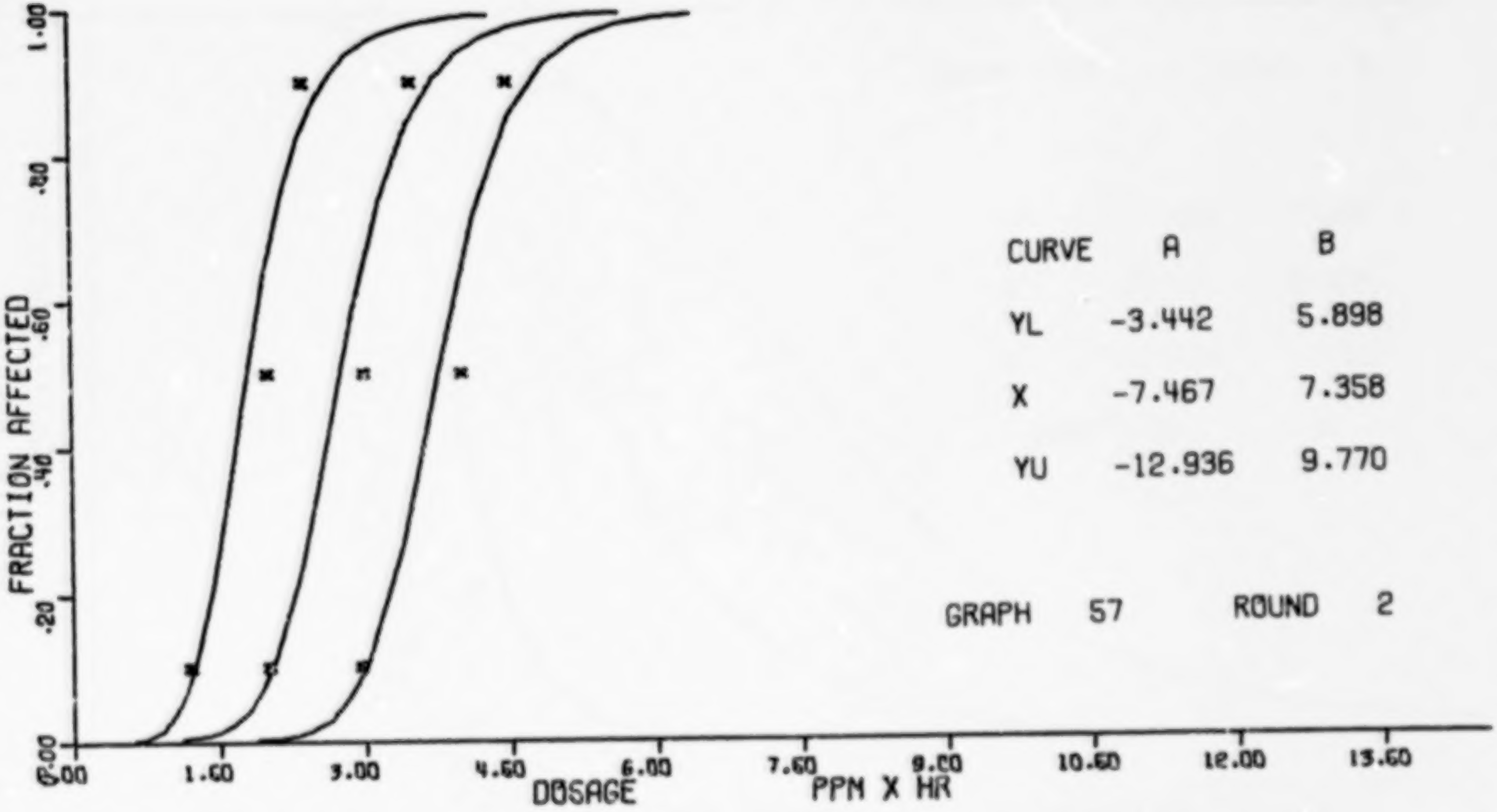
NITROGEN DIOXIDE HEART COND. SEV INCAPACITY = angina or a
myocardial infarction



NITROGEN DIOXIDE HEART COND. SEV DISABILITY = pulmonary edema



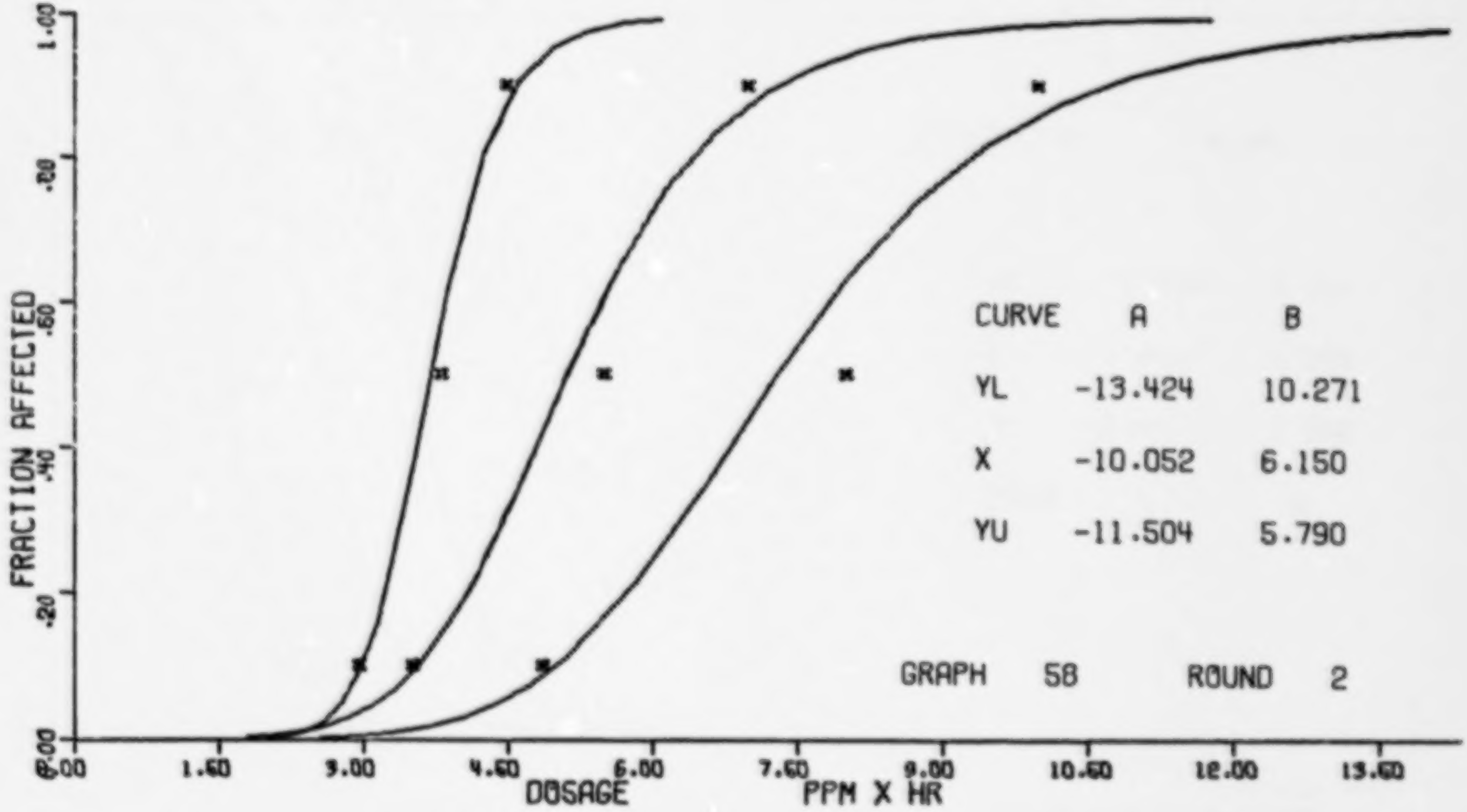
NITROGEN DIOXIDE **HEART COND. SEV** **DISCOMFORT** = worsening congestive heart failure



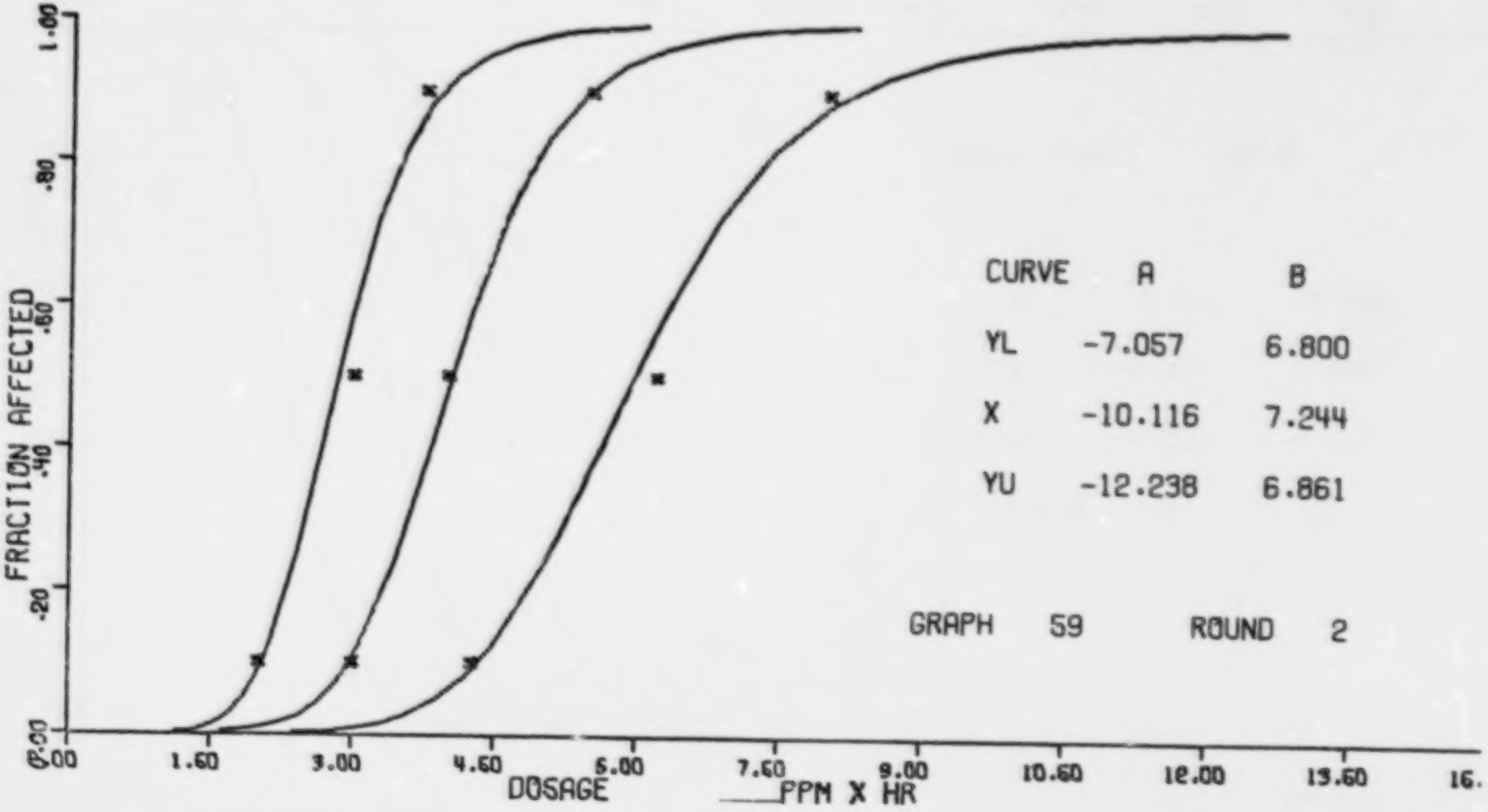
CURVE	A	B
YL	-3.442	5.898
X	-7.467	7.358
YU	-12.936	9.770

GRAPH 57 ROUND 2

NITROGEN DIOXIDE HAY FEVER. SINUS INCAPACITY = nasal or sinus drainage and headache



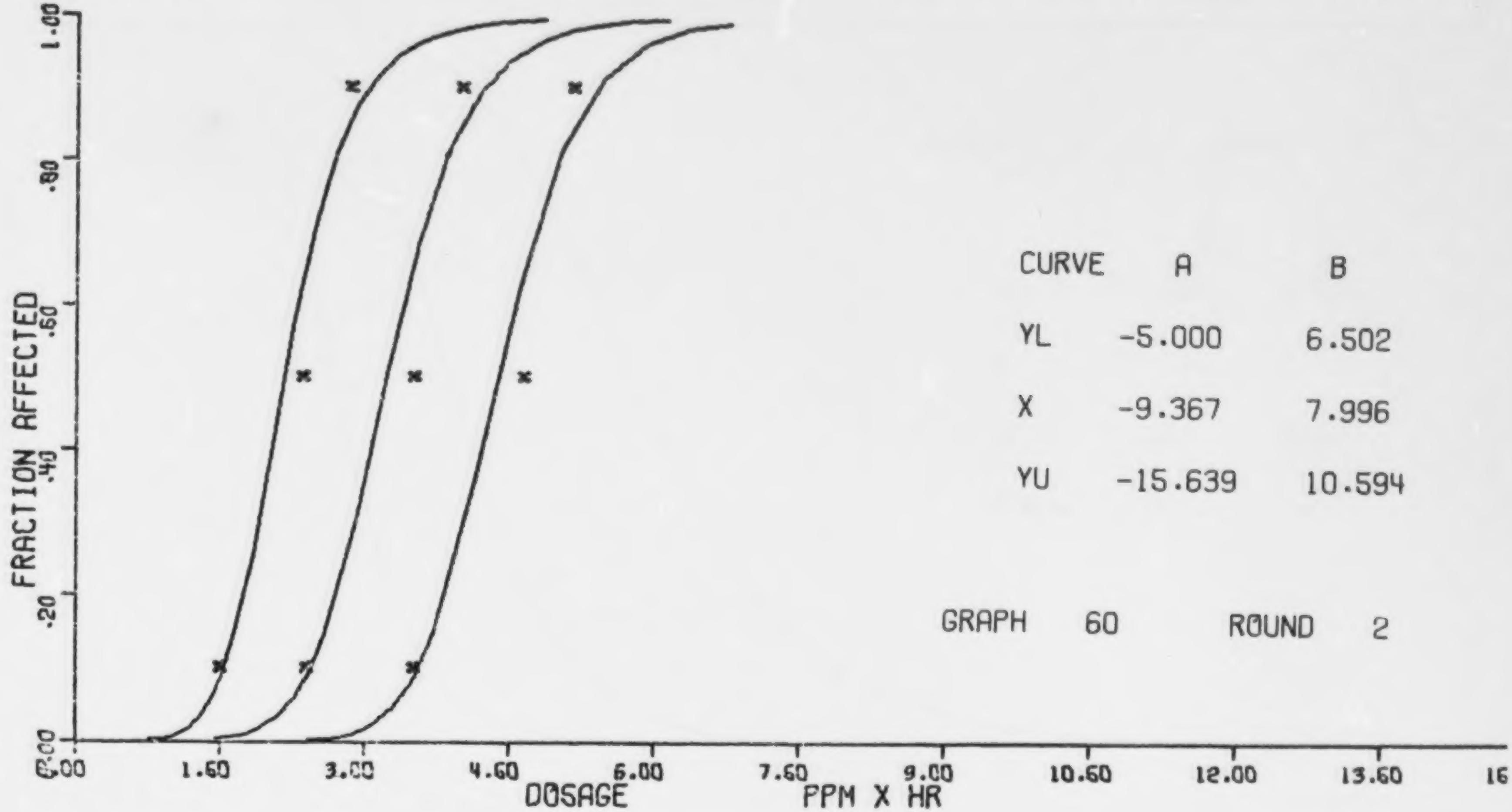
NITROGEN DIOXIDE HAY FEVER. SINUS DISABILITY = nasal or sinus drainage



CURVE	A	B
YL	-7.057	6.800
X	-10.116	7.244
YU	-12.238	6.861

GRAPH 59 ROUND 2

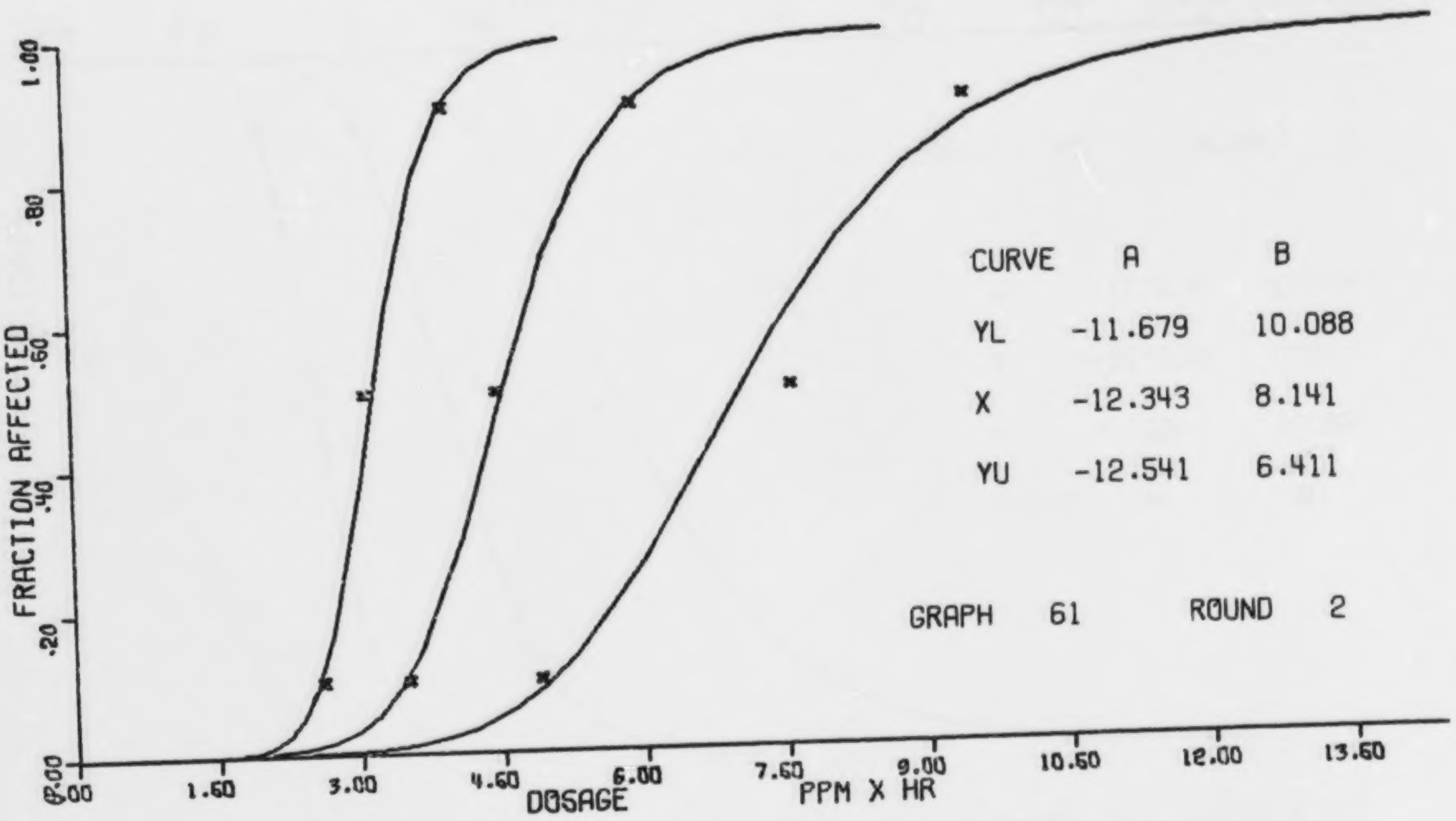
NITROGEN DIOXIDE HAY FEVER. SINUS DISCOMFORT = nasal or sinus discomfort

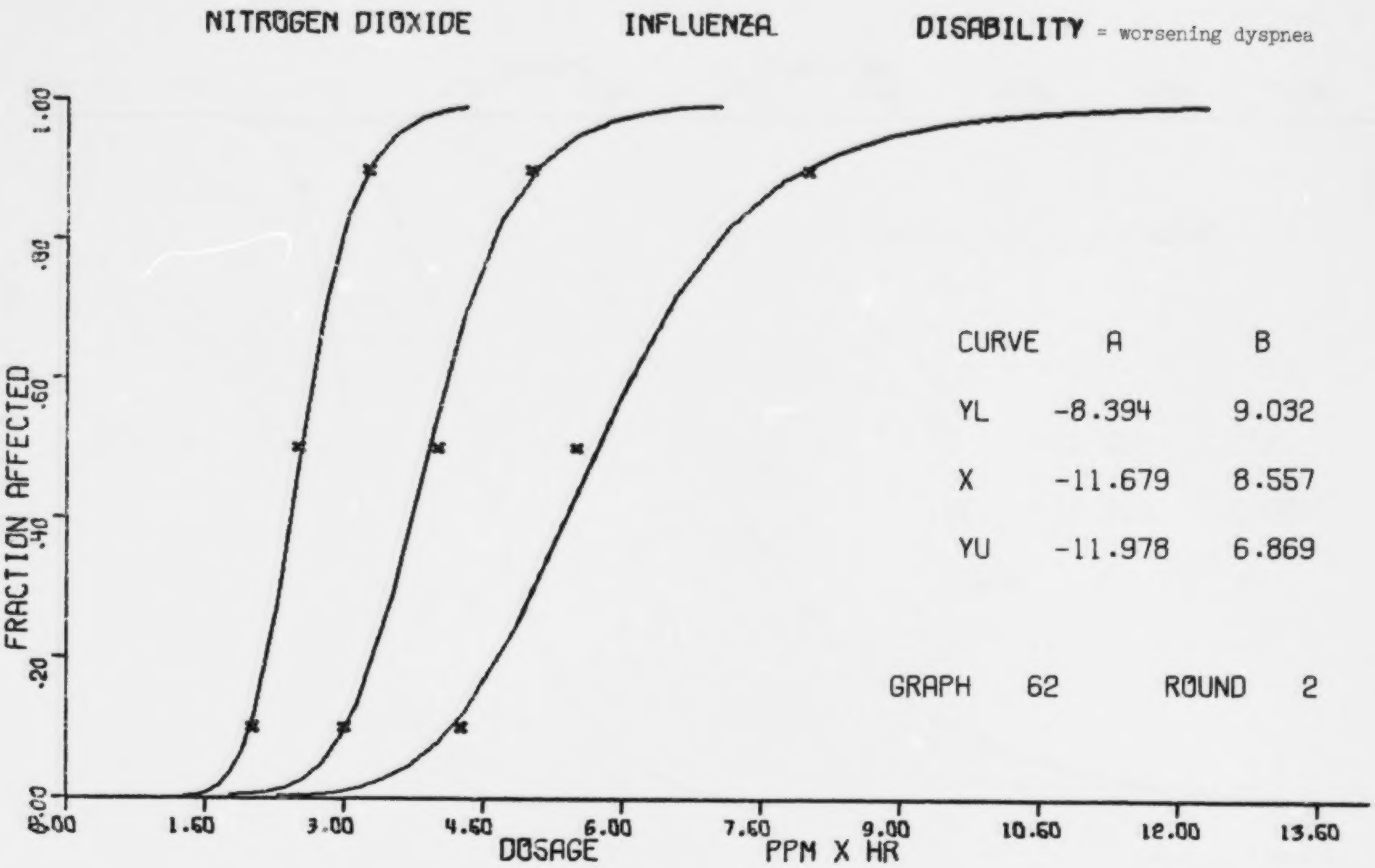


CURVE	A	B
YL	-5.000	6.502
X	-9.367	7.996
YU	-15.639	10.594

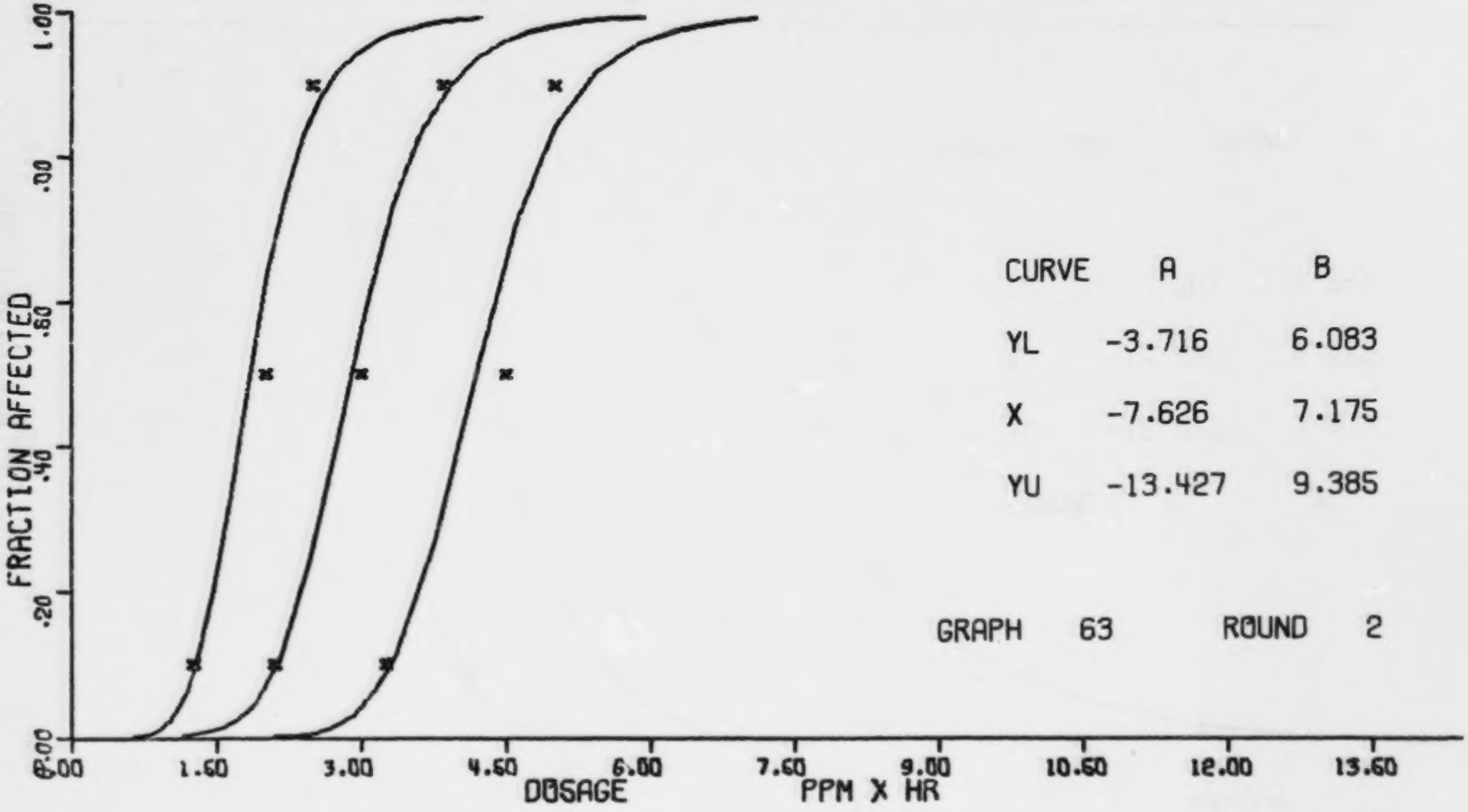
GRAPH 60 ROUND 2

NITROGEN DIOXIDE INFLUENZA INCAPACITY = superimposed bacterial pneumonia




NITROGEN DIOXIDE
INFLUENZA
DISABILITY = worsening dyspnea
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.60
3.00
4.60
6.00
7.60
9.00
10.60
12.00
13.60
DOSAGE
PPM X HR
CURVE A B
YL -8.394 9.032
X -11.679 8.557
YU -11.978 6.869
GRAPH 62
ROUND 2

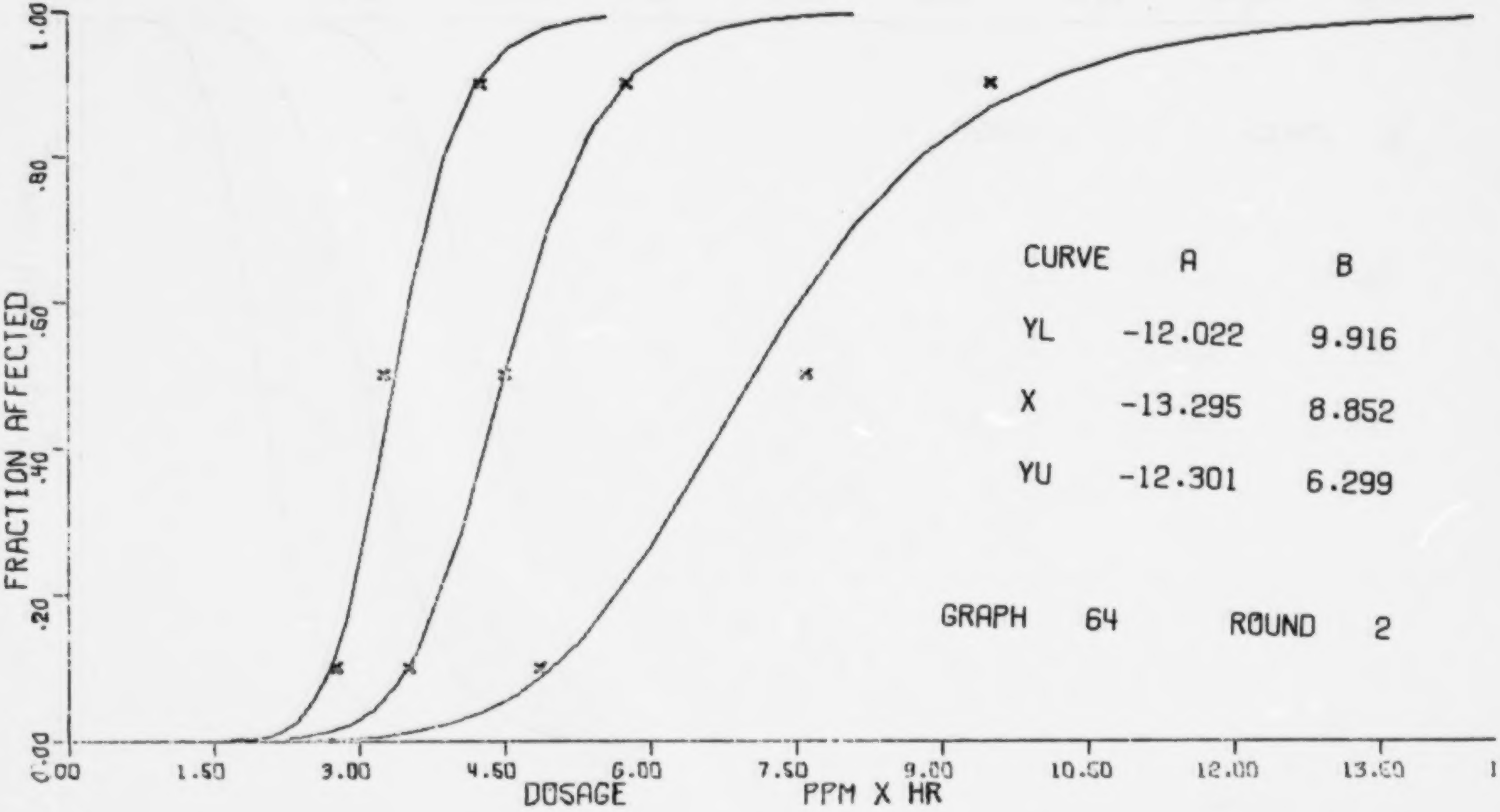
NITROGEN DIOXIDE **INFLUENZA** **DISCOMFORT** = increased cough and pleuritic pain

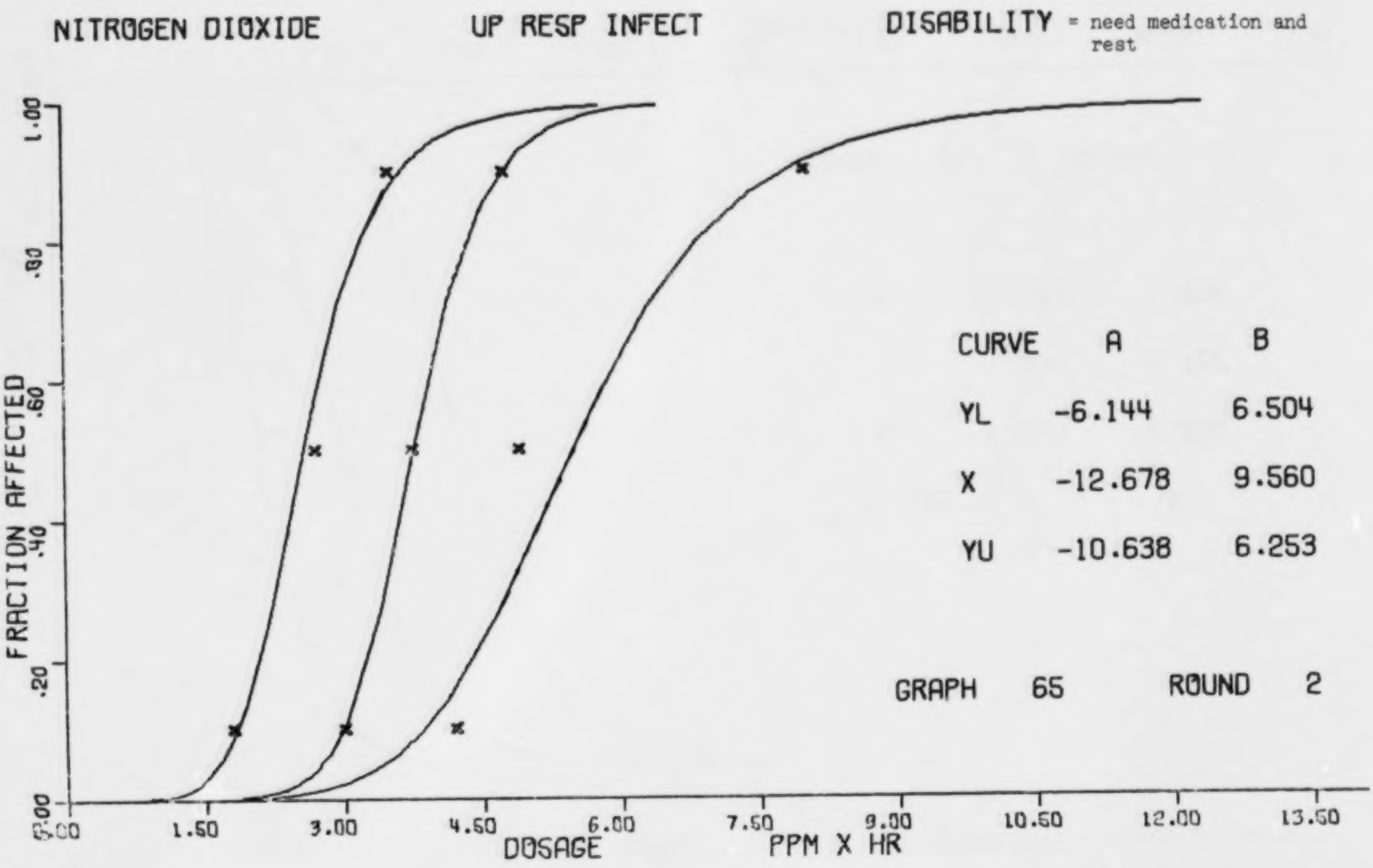


CURVE	A	B
YL	-3.716	6.083
X	-7.626	7.175
YU	-13.427	9.385

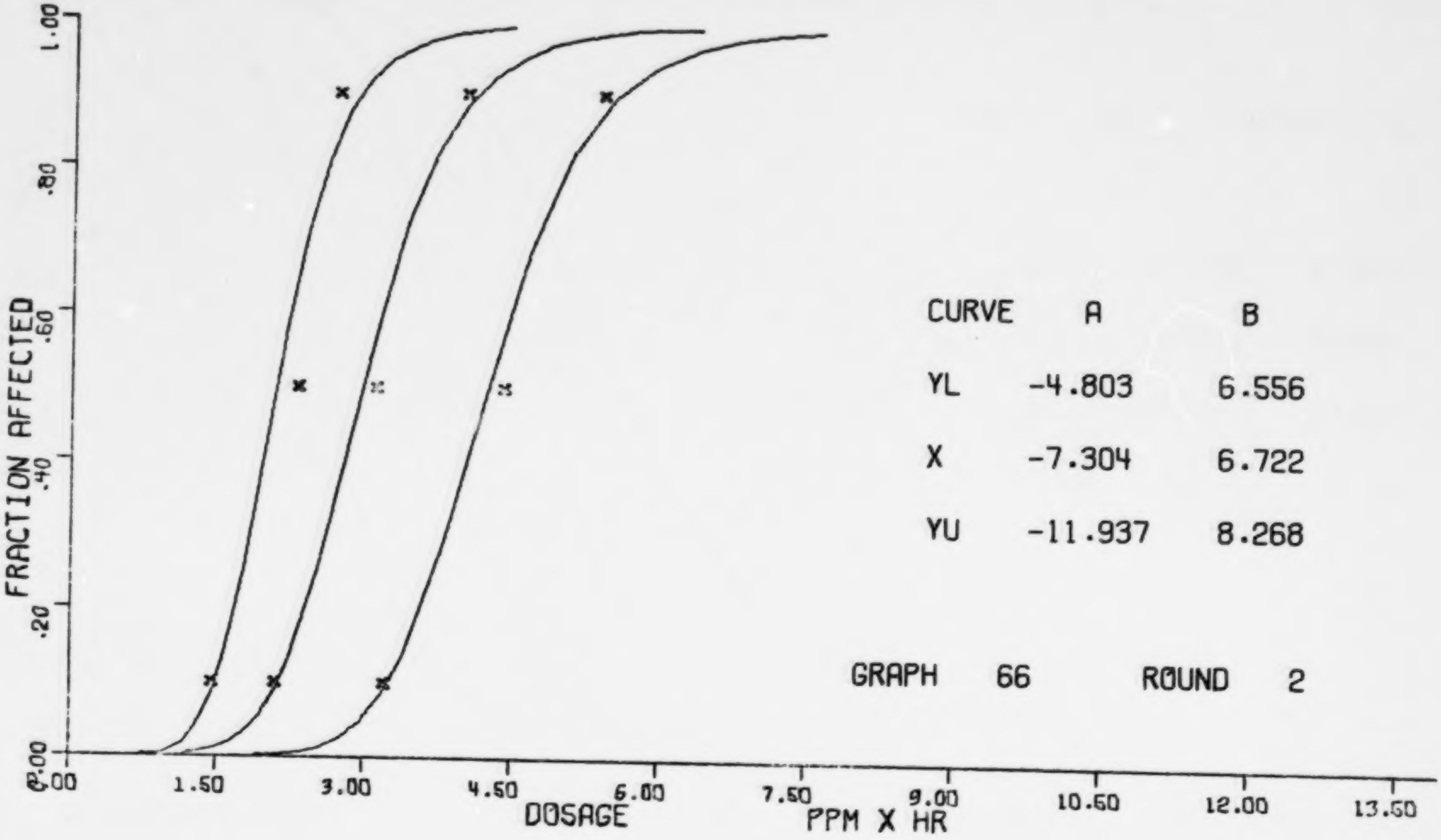
GRAPH 63 ROUND 2

NITROGEN DIOXIDE UP RESP INFECT INCAPACITY = secondary bacterial infection



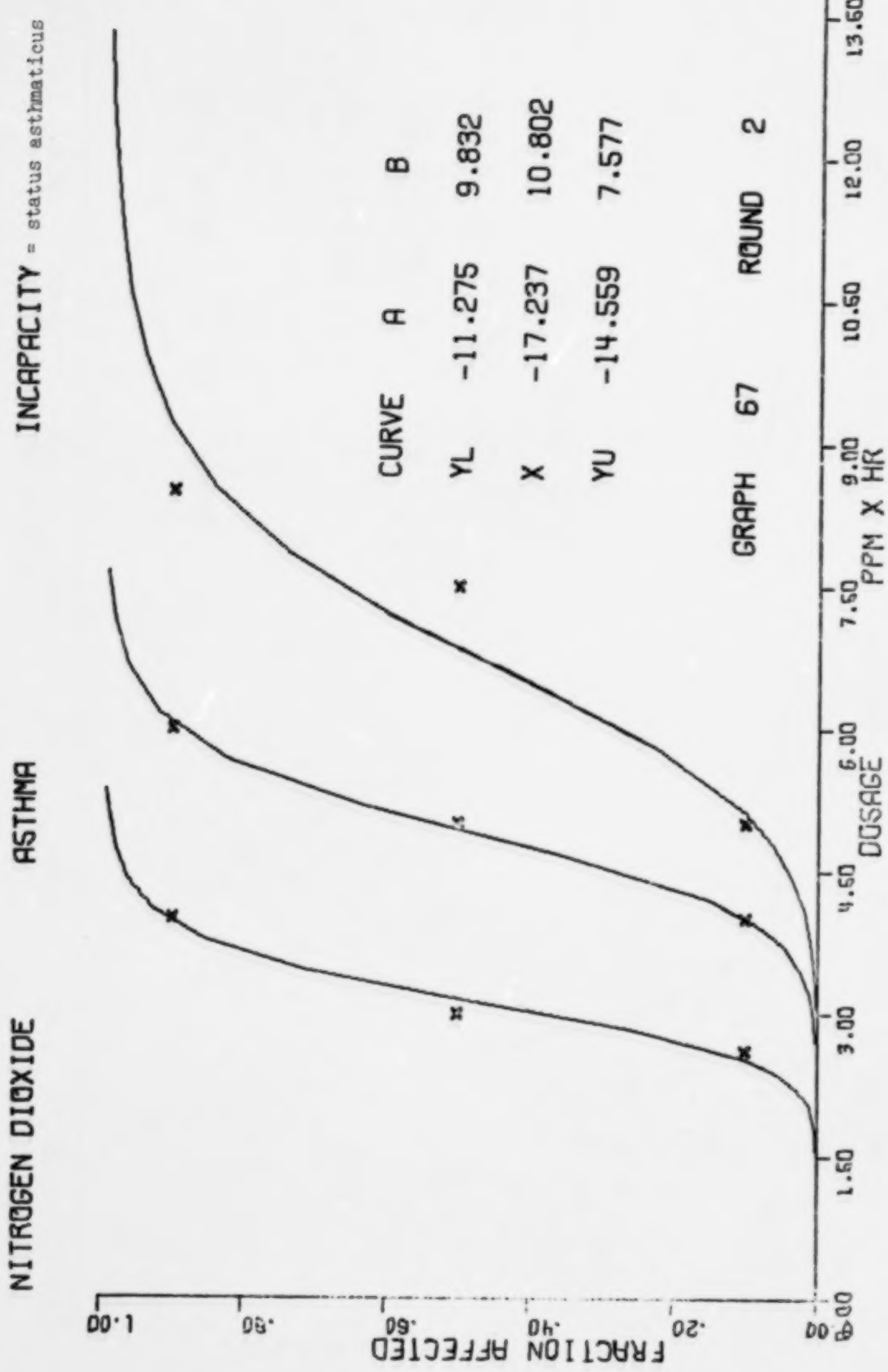

NITROGEN DIOXIDE
UP RESP INFECT
DISABILITY = need medication and rest
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
13.50
DOSAGE
PPM X HR
CURVE A B
YL -6.144 6.504
X -12.678 9.560
YU -10.638 6.253
GRAPH 65
ROUND 2

NITROGEN DIOXIDE UP RESP INFECT DISCOMFORT = worsening symptoms

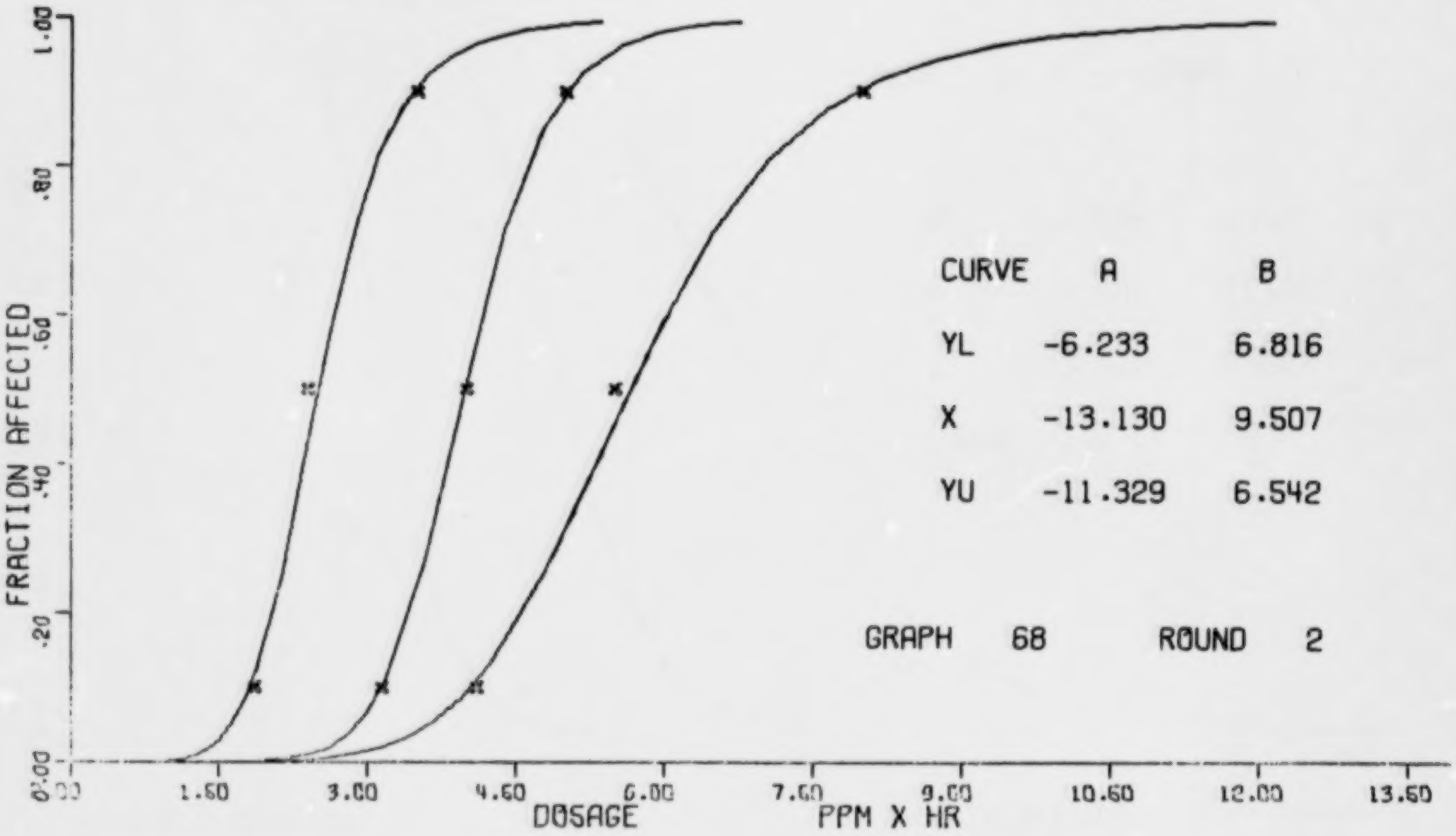


CURVE	A	B
YL	-4.803	6.556
X	-7.304	6.722
YU	-11.937	8.268

GRAPH 66 ROUND 2

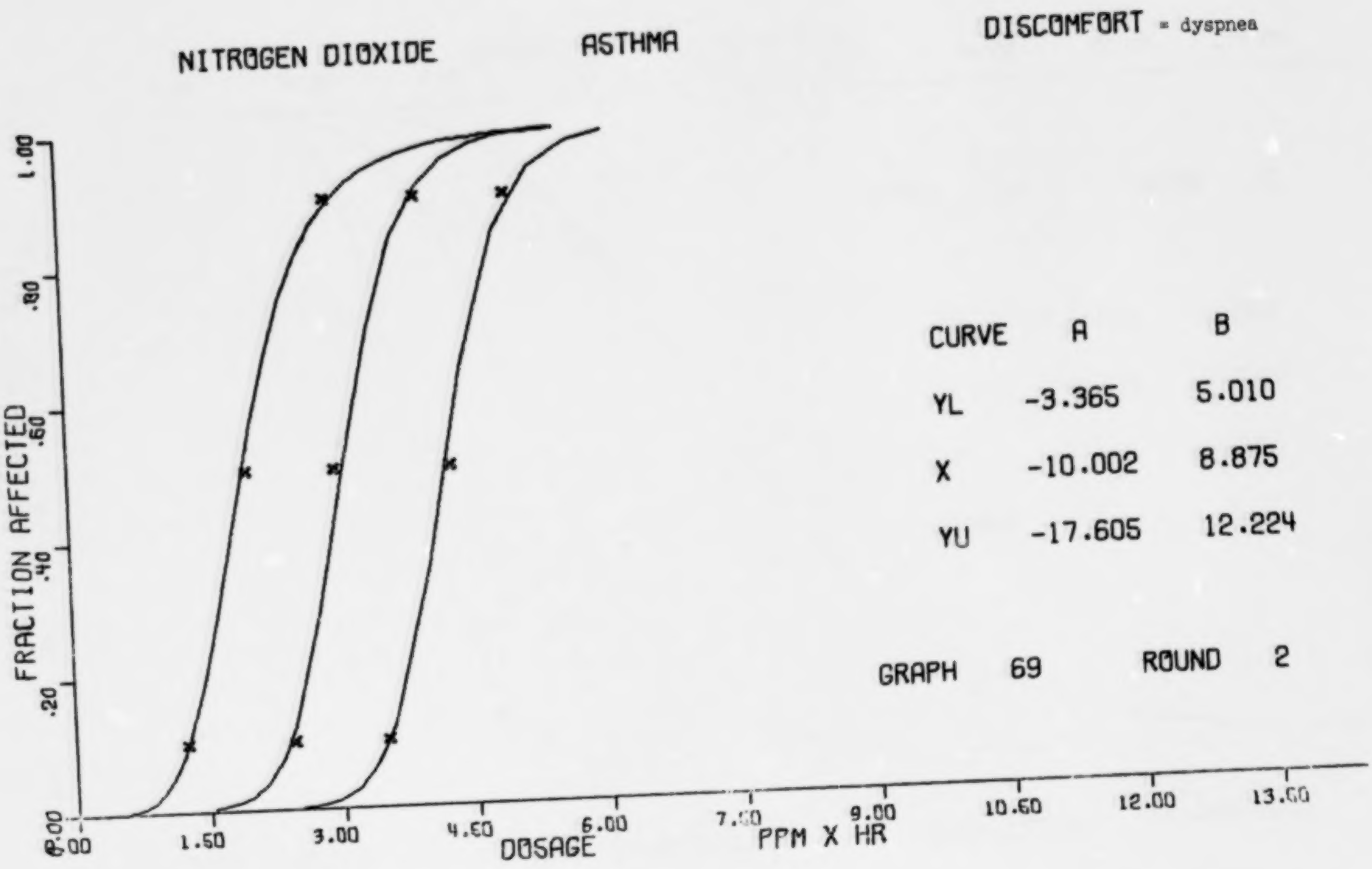

NITROGEN DIOXIDE
ASTHMA
INCAPACITY = status asthmaticus
CURVE A B
YL -11.275 9.832
X -17.237 10.802
YU -14.559 7.577
GRAPH 67 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
13.60

NITROGEN DIOXIDE ASTHMA DISABILITY = asthmatic attack



CURVE	A	B
YL	-6.233	6.816
X	-13.130	9.507
YU	-11.329	6.542

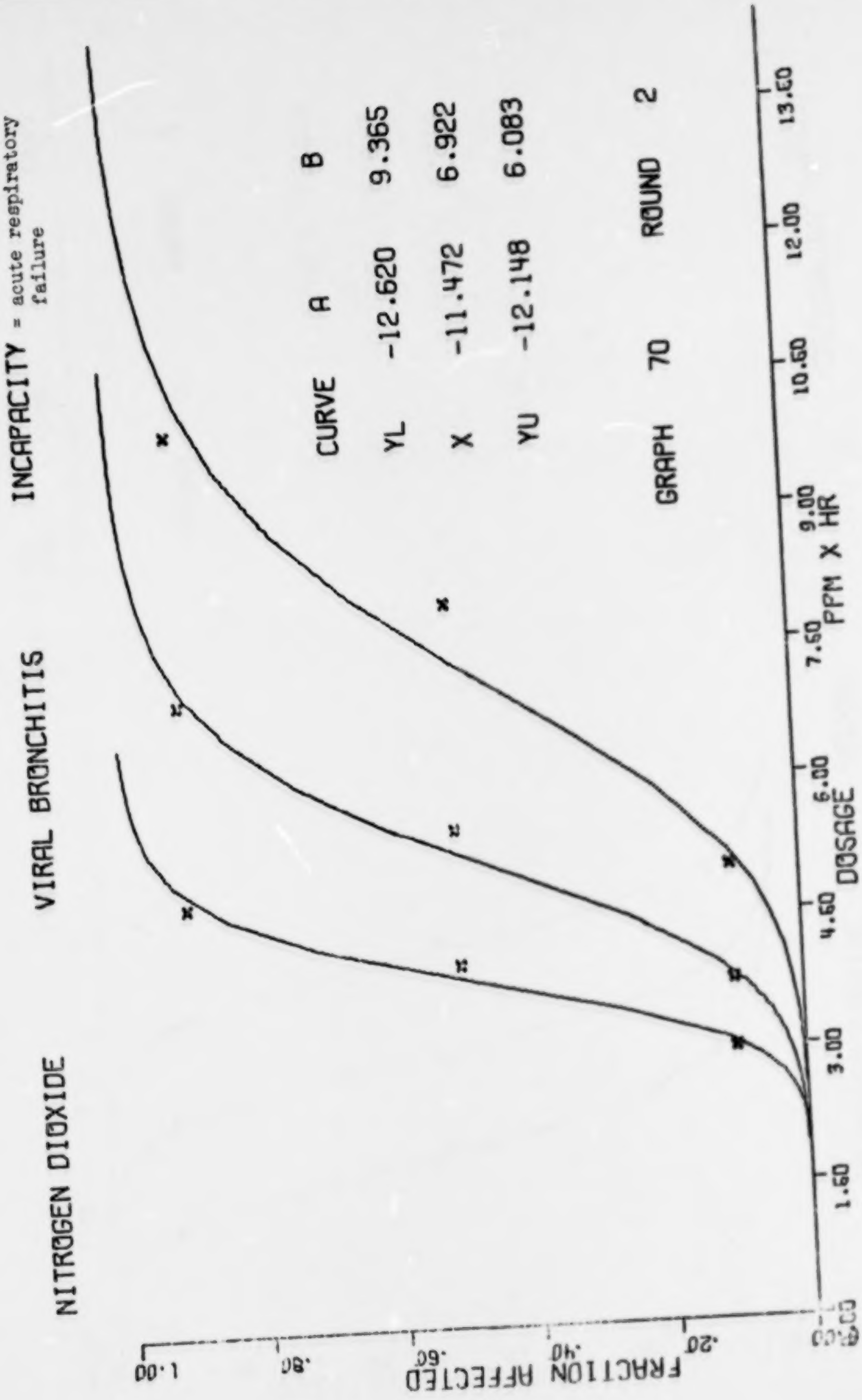
GRAPH 68 ROUND 2



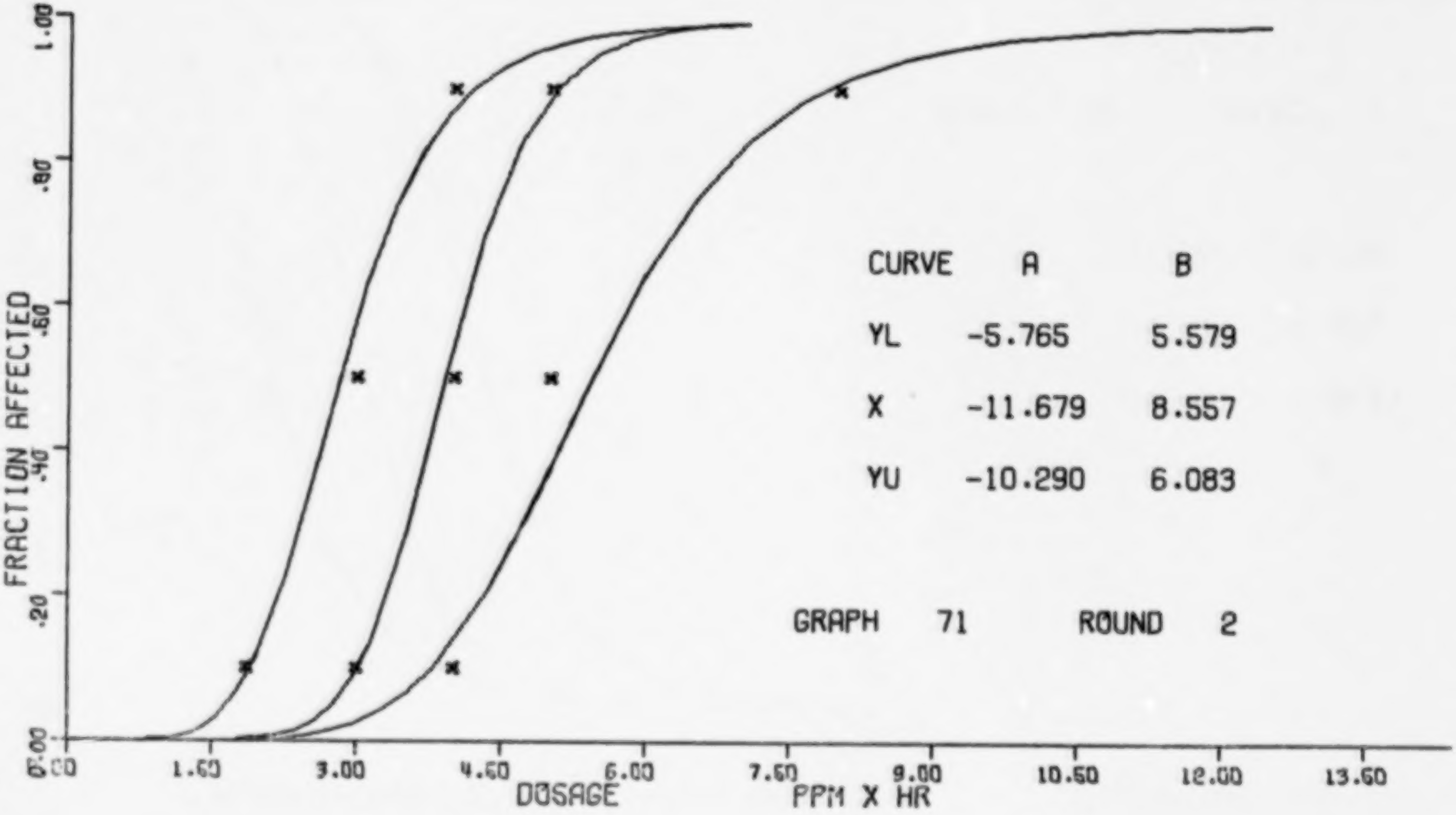
NITROGEN DIOXIDE ASTHMA DISCOMFORT = dyspnea

CURVE	A	B
YL	-3.365	5.010
X	-10.002	8.875
YU	-17.605	12.224

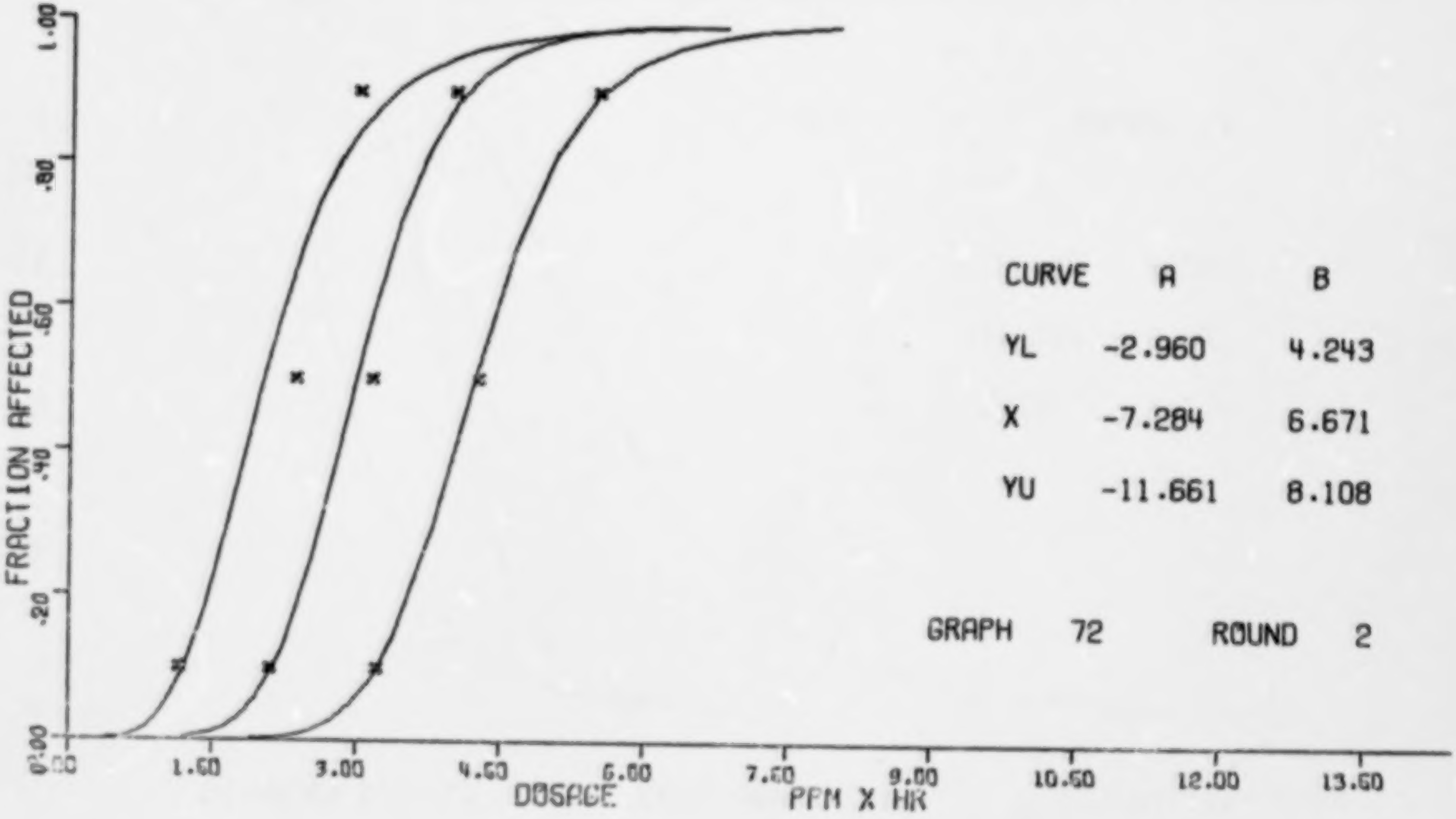
GRAPH 69 ROUND 2


NITROGEN DIOXIDE
VIRAL BRONCHITIS
INCAPACITY = acute respiratory failure
CURVE A B
YL -12.620 9.365
X -11.472 6.922
YU -12.148 6.083
GRAPH 70 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE PPM X HR
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
13.50

NITROGEN DIOXIDE VIRAL BRONCHITIS DISABILITY = dyspnea

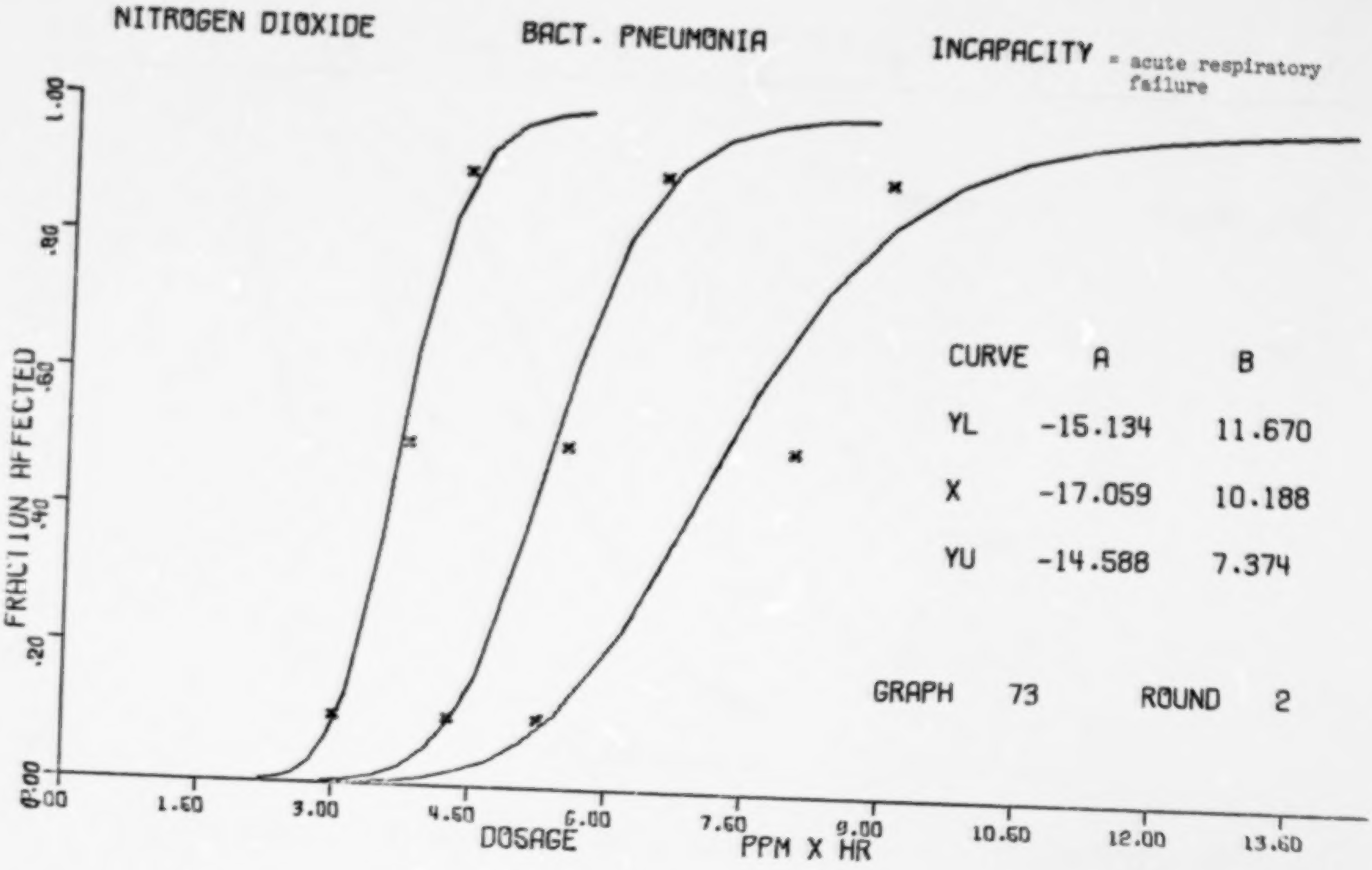


NITROGEN DIOXIDE VIRAL BRONCHITIS DISCOMFORT = cough

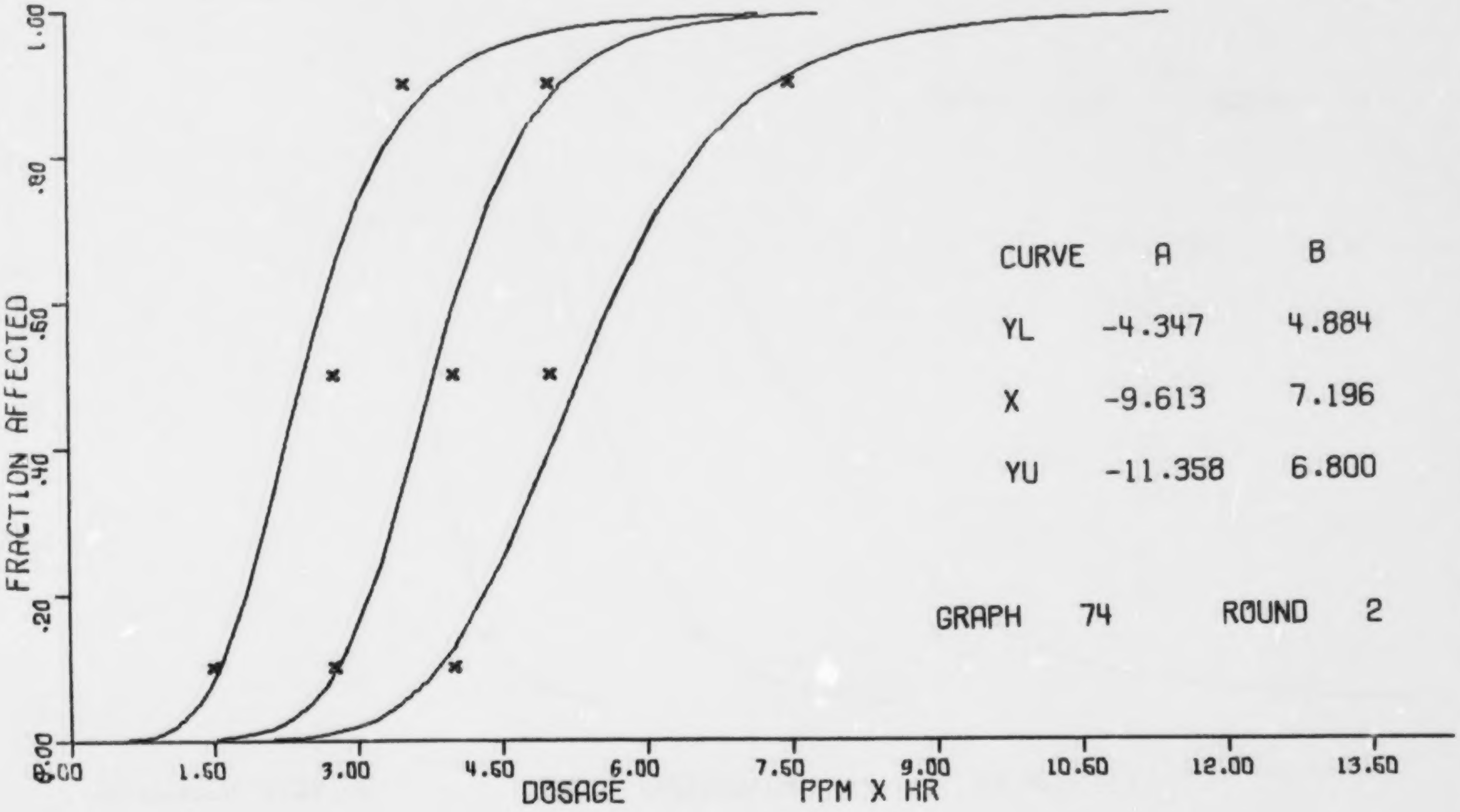


CURVE	A	B
YL	-2.960	4.243
X	-7.284	6.671
YU	-11.661	8.108

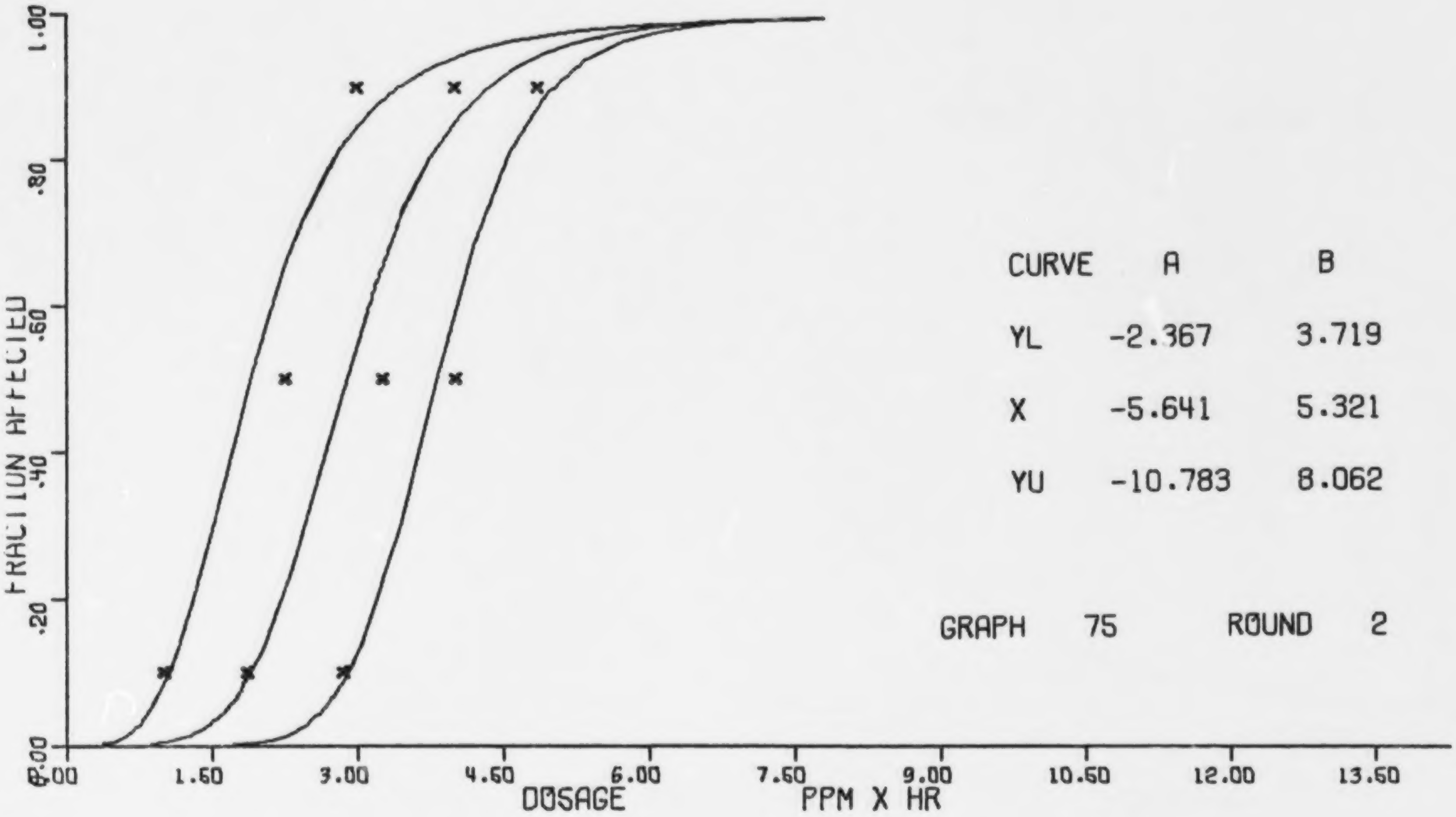
GRAPH 72 ROUND 2


NITROGEN DIOXIDE
BACT. PNEUMONIA
INCAPACITY = acute respiratory failure
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.60
3.00
4.60
6.00
7.60
9.00
10.60
12.00
13.60
DOSAGE
PPM X HR
CURVE A B
YL -15.134 11.670
X -17.059 10.188
YU -14.588 7.374
GRAPH 73
ROUND 2

NITROGEN DIOXIDE BACT.- PNEUMONIA DISABILITY = dyspnea



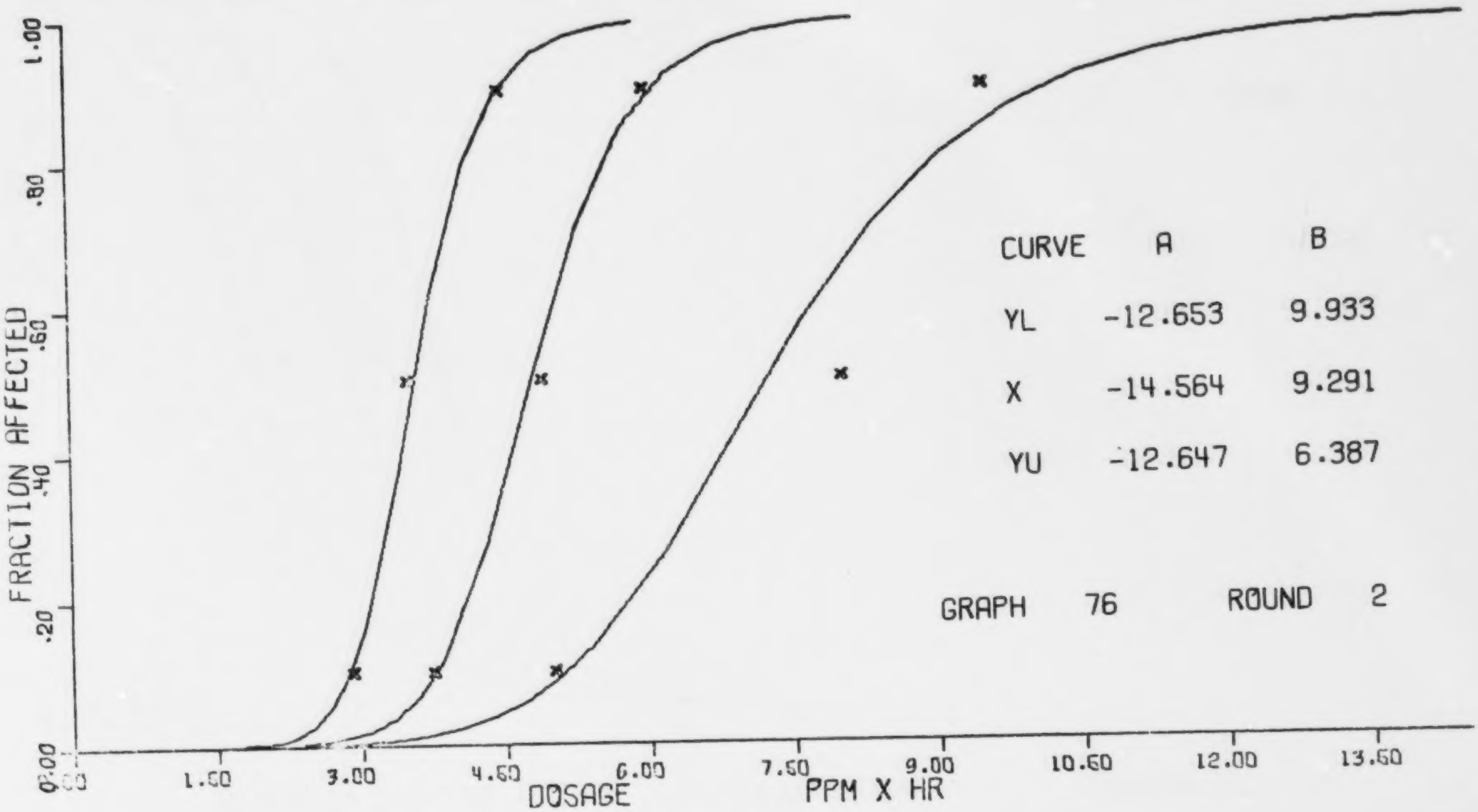
NITROGEN DIOXIDE BACT. PNEUMONIA DISCOMFORT = cough



CURVE	A	B
YL	-2.367	3.719
X	-5.641	5.321
YU	-10.783	8.062

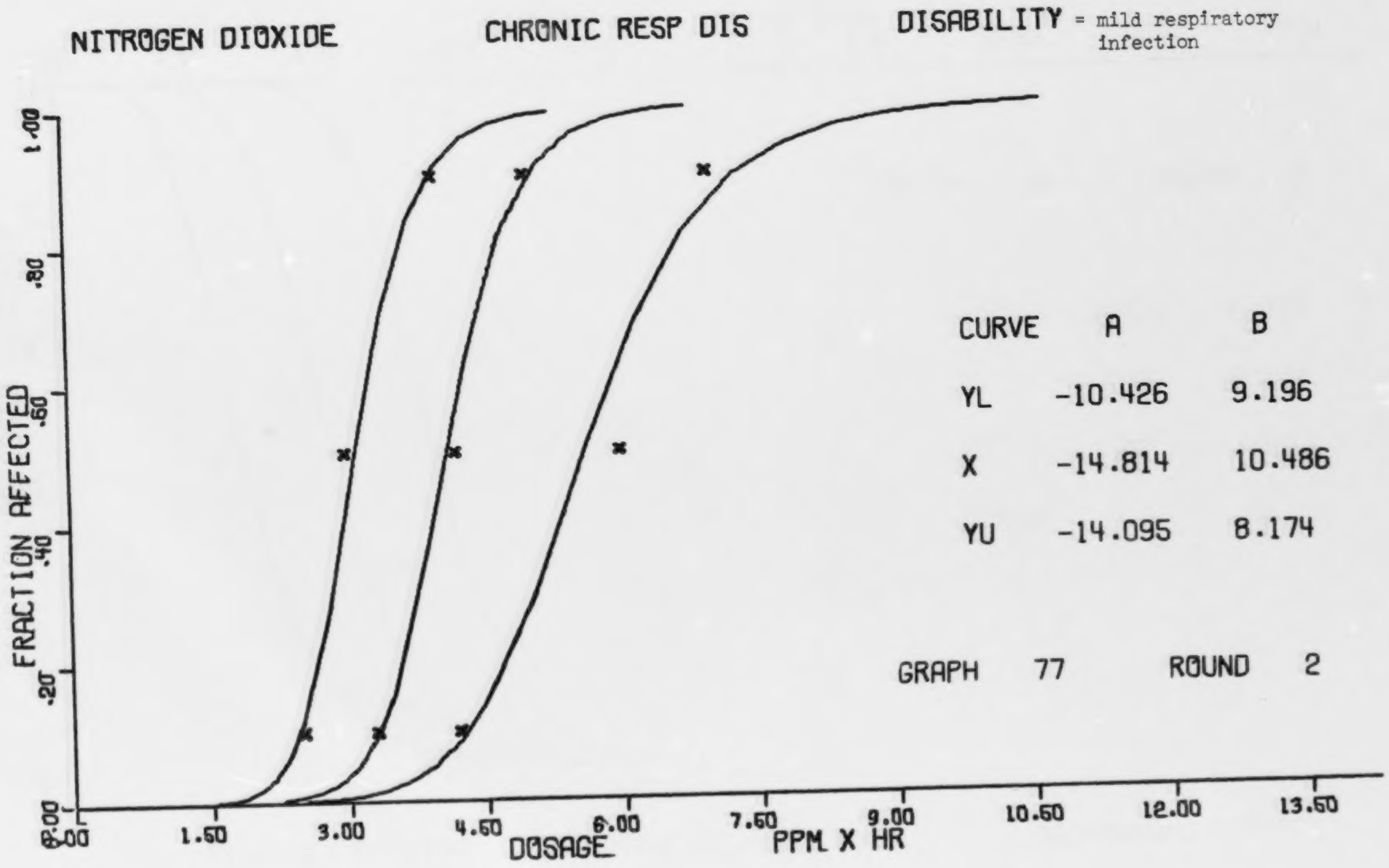
GRAPH 75 ROUND 2

NITROGEN DIOXIDE CHRONIC RESP DIS INCAPACITY = pneumonia

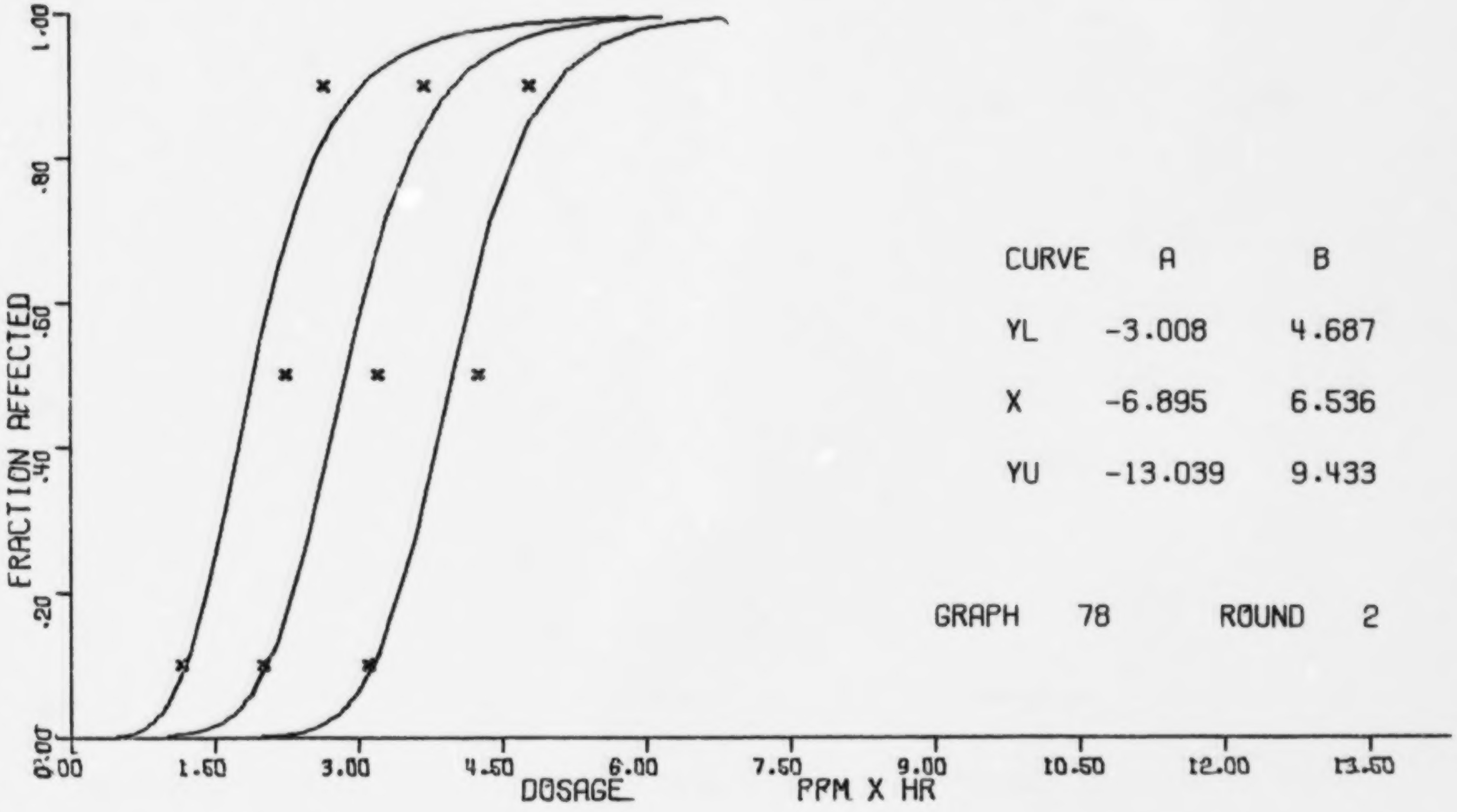


CURVE	A	B
YL	-12.653	9.933
X	-14.564	9.291
YU	-12.647	6.387

GRAPH 76 ROUND 2


NITROGEN DIOXIDE
CHRONIC RESP DIS
DISABILITY = mild respiratory infection
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
13.50
DOSAGE
PPM X HR
CURVE A B
YL -10.426 9.196
X -14.814 10.486
YU -14.095 8.174
GRAPH 77
ROUND 2

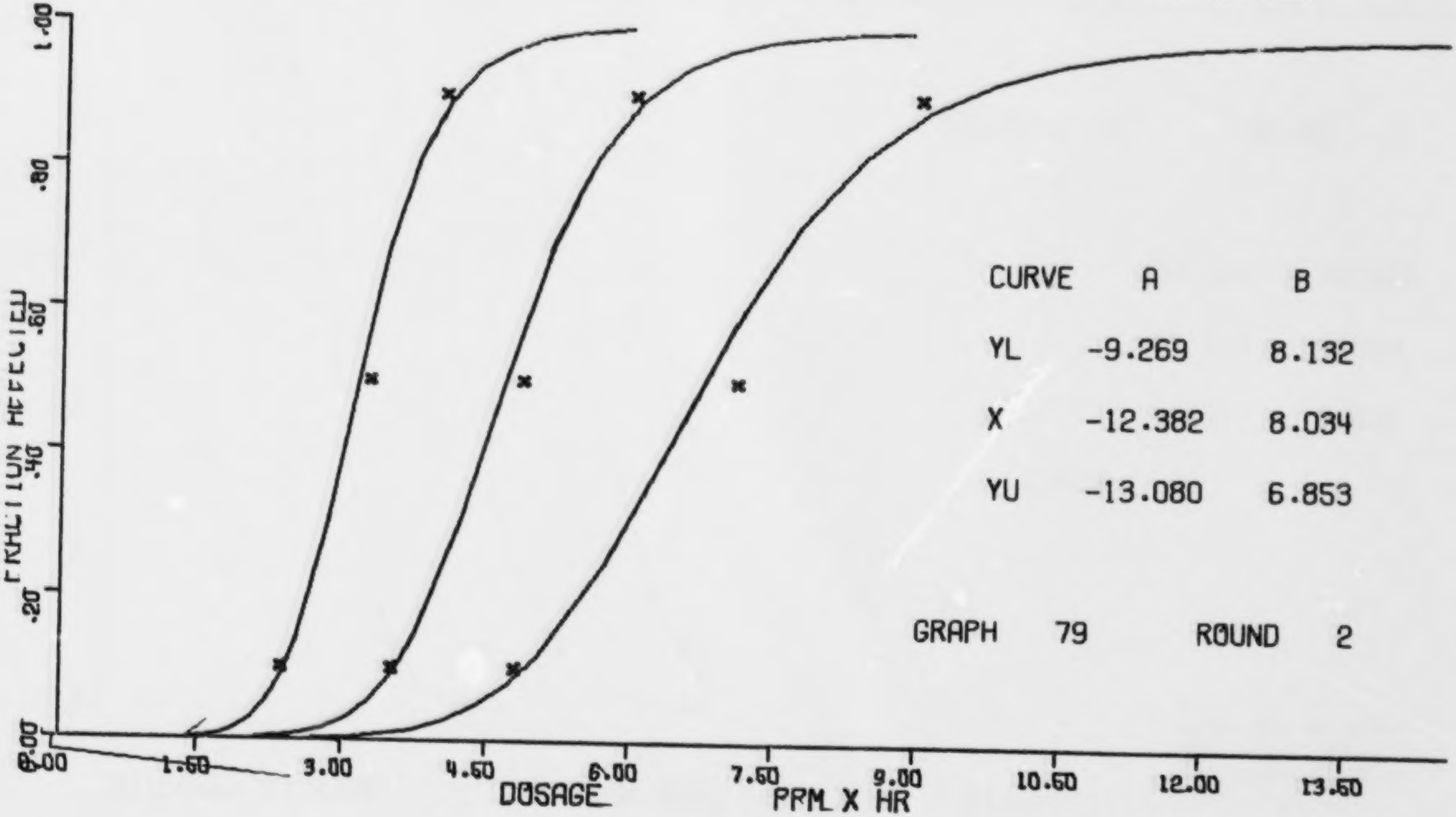
NITROGEN DIOXIDE CHRONIC RESP DIS DISCOMFORT = dyspnea



CURVE	A	B
YL	-3.008	4.687
X	-6.895	6.536
YU	-13.039	9.433

GRAPH 78 ROUND 2

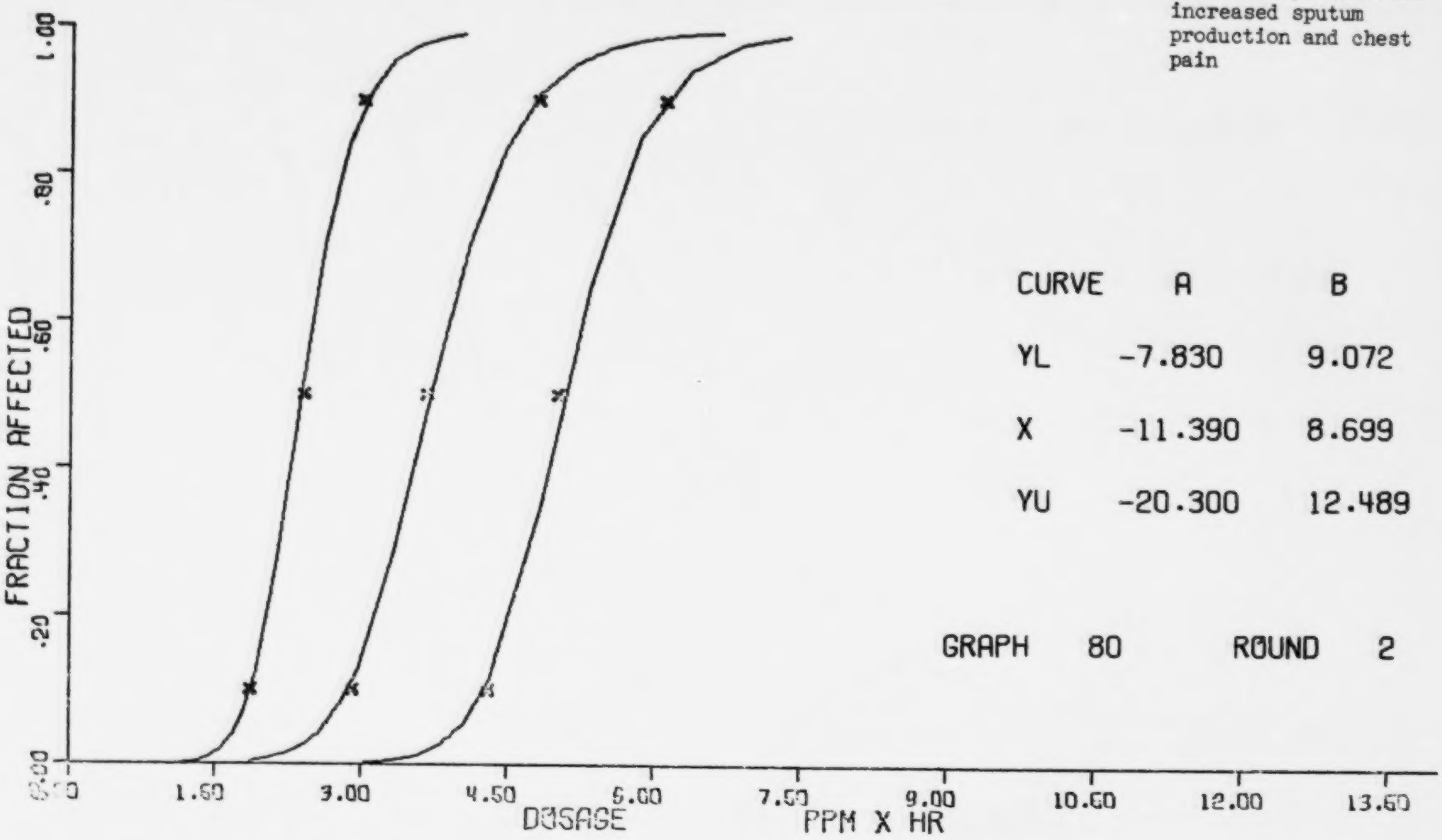
NITROGEN DIOXIDE   M CHRN OBST LUNG   INCAPACITY = broncho-pneumonia, cor pulmonale



CURVE	A	B
YL	-9.269	8.132
X	-12.382	8.034
YU	-13.080	6.853

GRAPH 79   ROUND 2

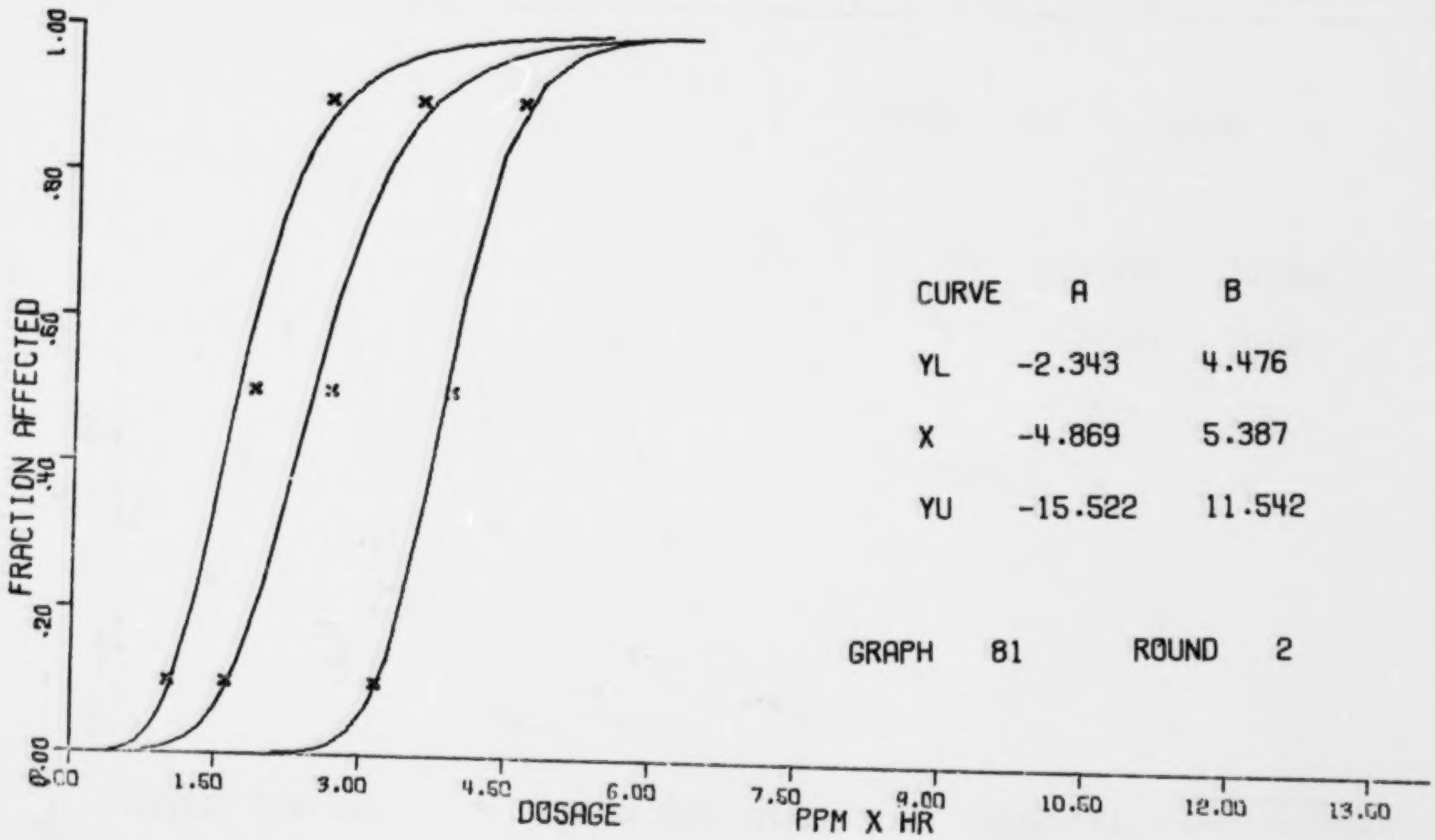
NITROGEN DIOXIDE M CHRN OBST LUNG DISABILITY = exacerbation of bronchitis, fever and increased sputum production and chest pain



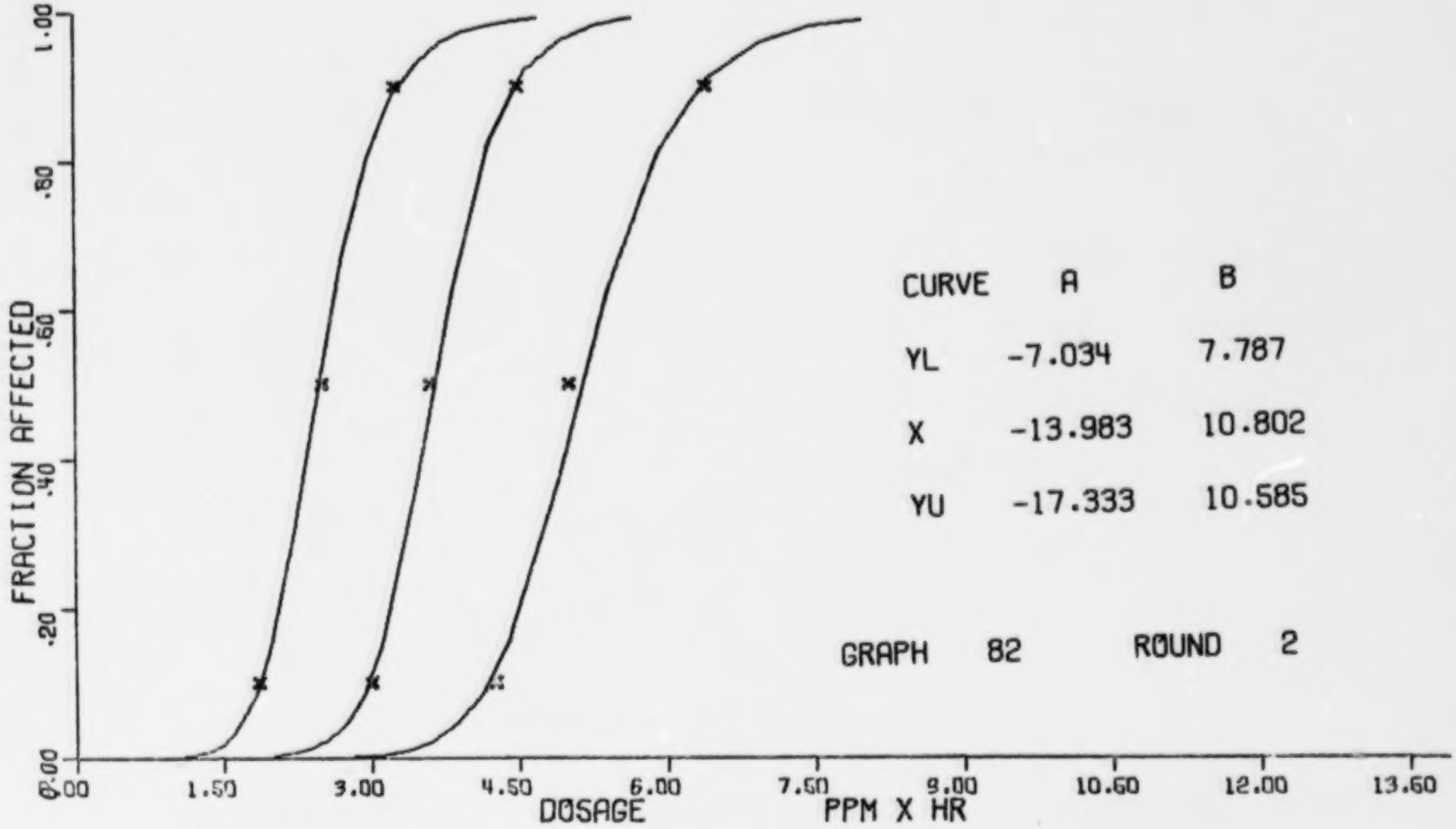
CURVE	A	B
YL	-7.830	9.072
X	-11.390	8.699
YU	-20.300	12.489

GRAPH 80 ROUND 2

NITROGEN DIOXIDE M CHRN OBST LUNG DISCOMFORT = dyspnea

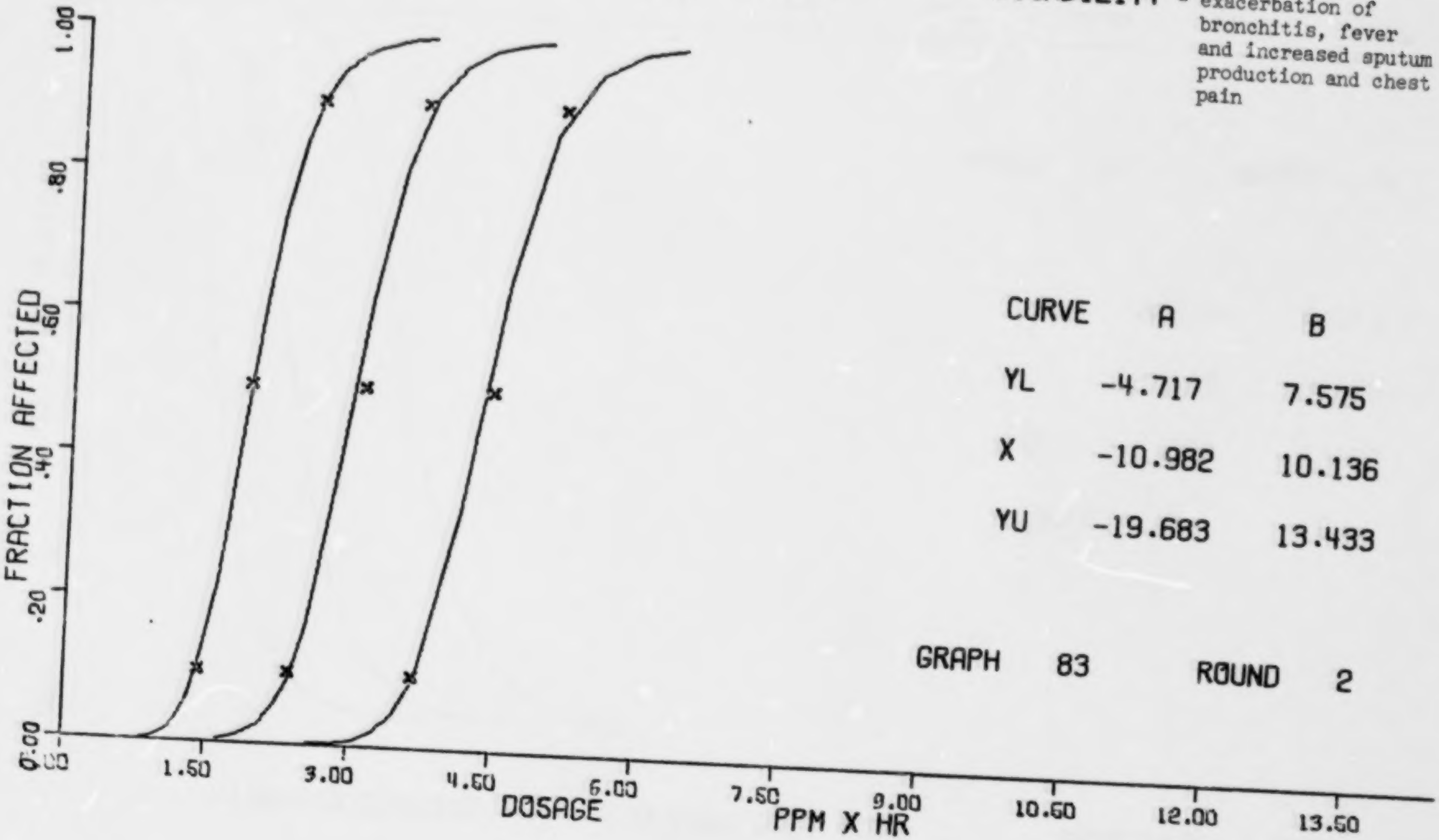


NITROGEN DIOXIDE   S CHRN OBST LUNG   INCAPACITY = broncho-pneumonia,
cor pulmonale



NITROGEN DIOXIDE S CHRN OBST LUNG

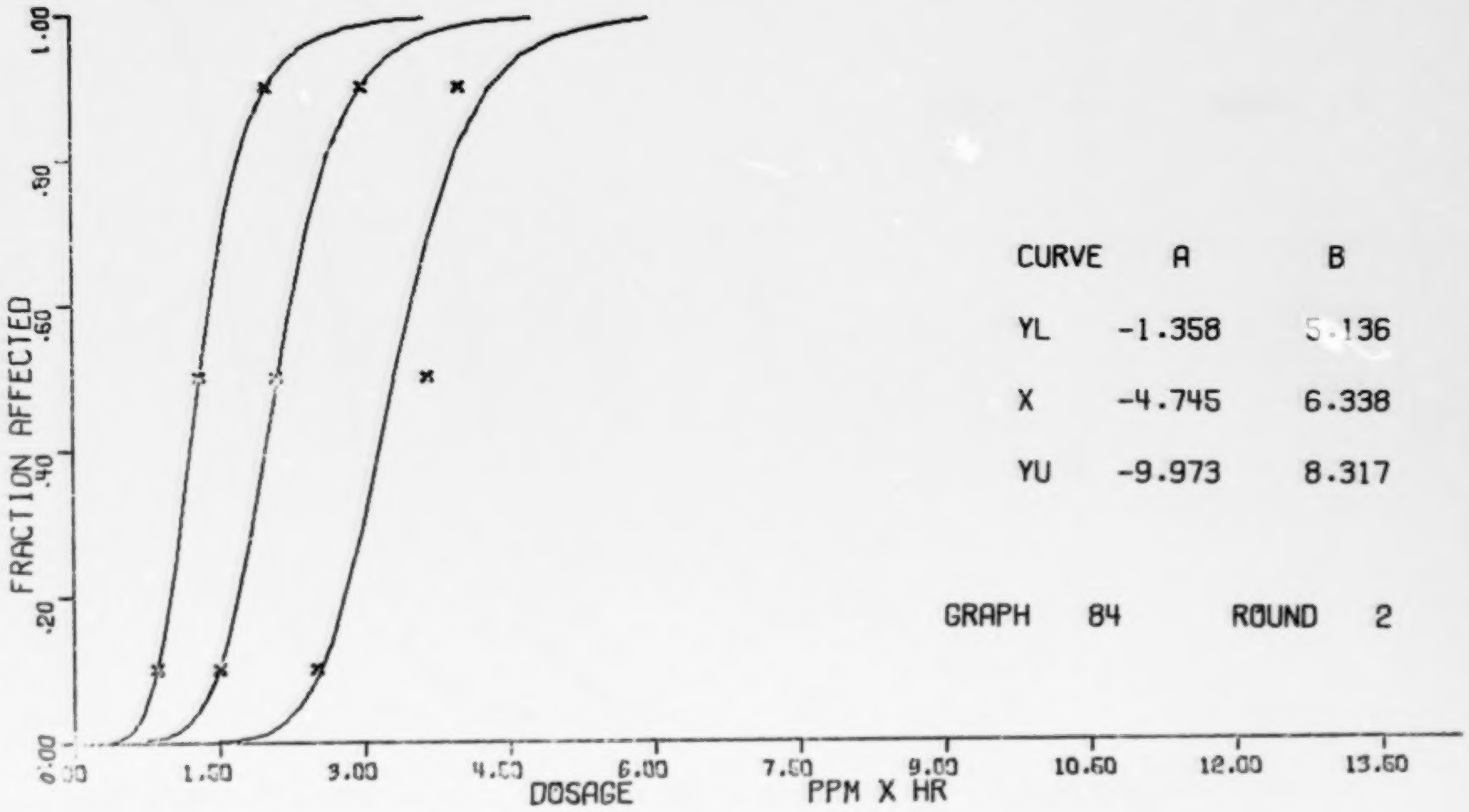
DISABILITY = exacerbation of bronchitis, fever and increased sputum production and chest pain



CURVE	A	B
YL	-4.717	7.575
X	-10.982	10.136
YU	-19.683	13.433

GRAPH 83 ROUND 2

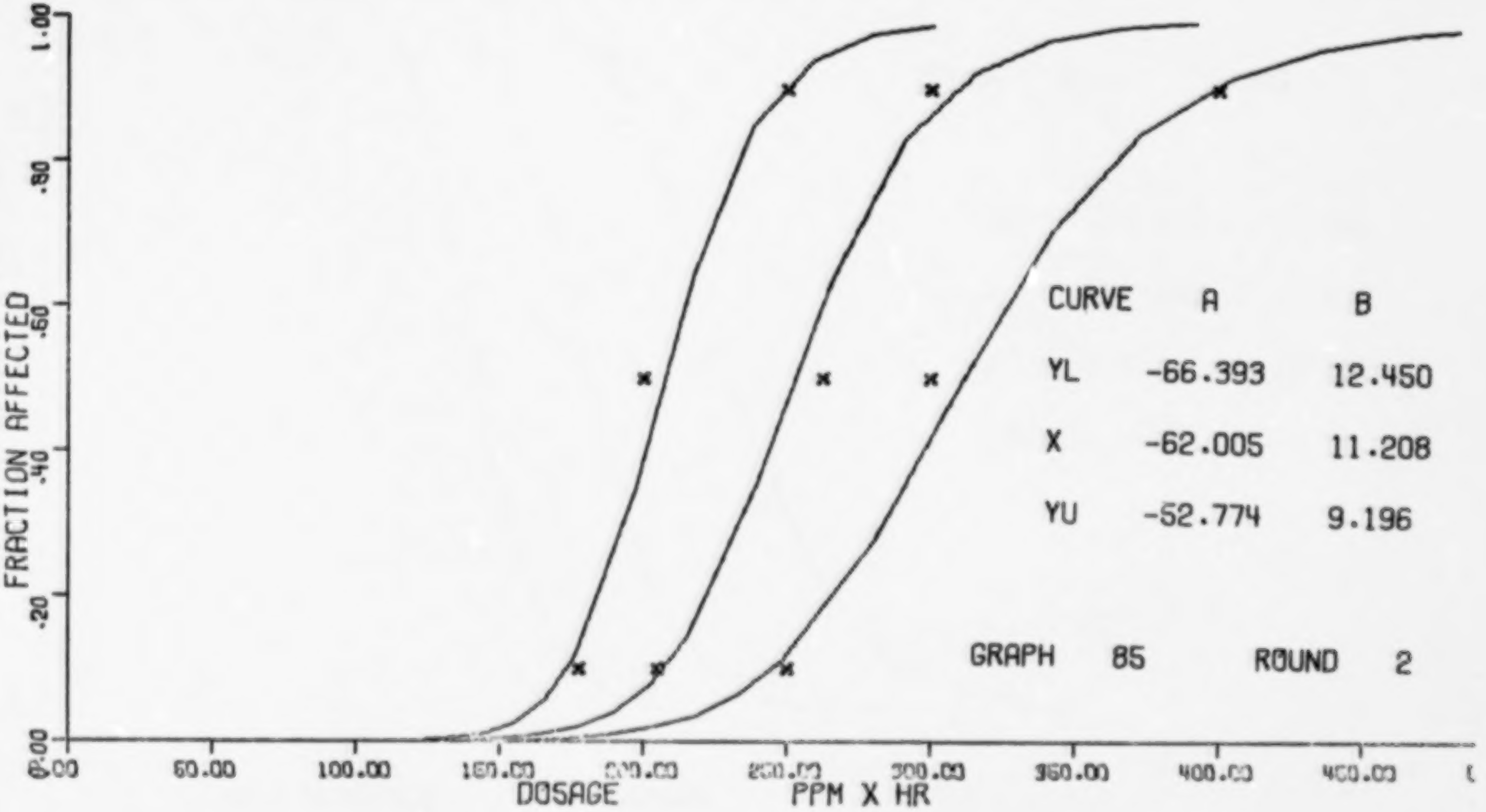
NITROGEN DIOXIDE S CHRN OBST LUNG DISCOMFORT = dyspnea

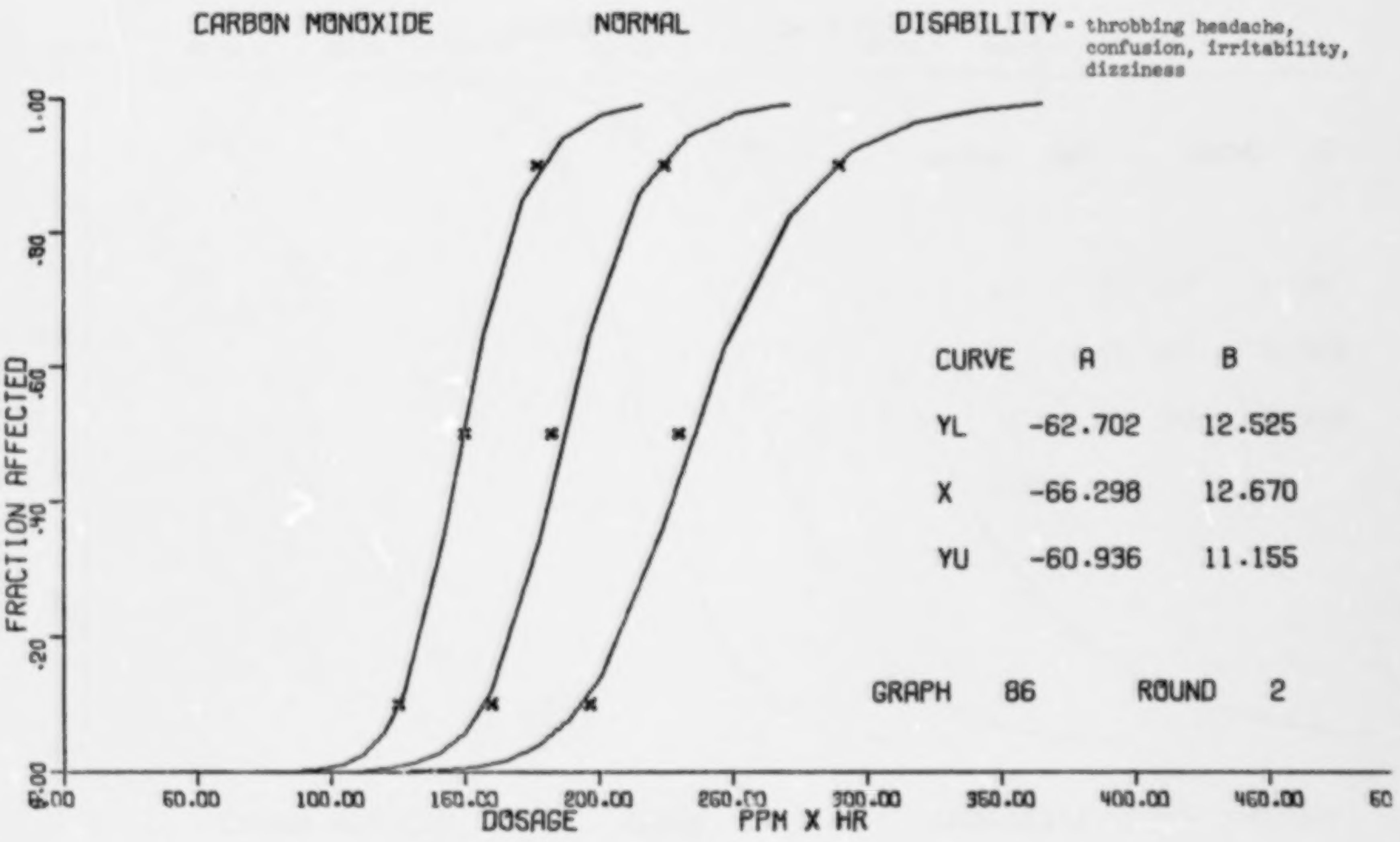


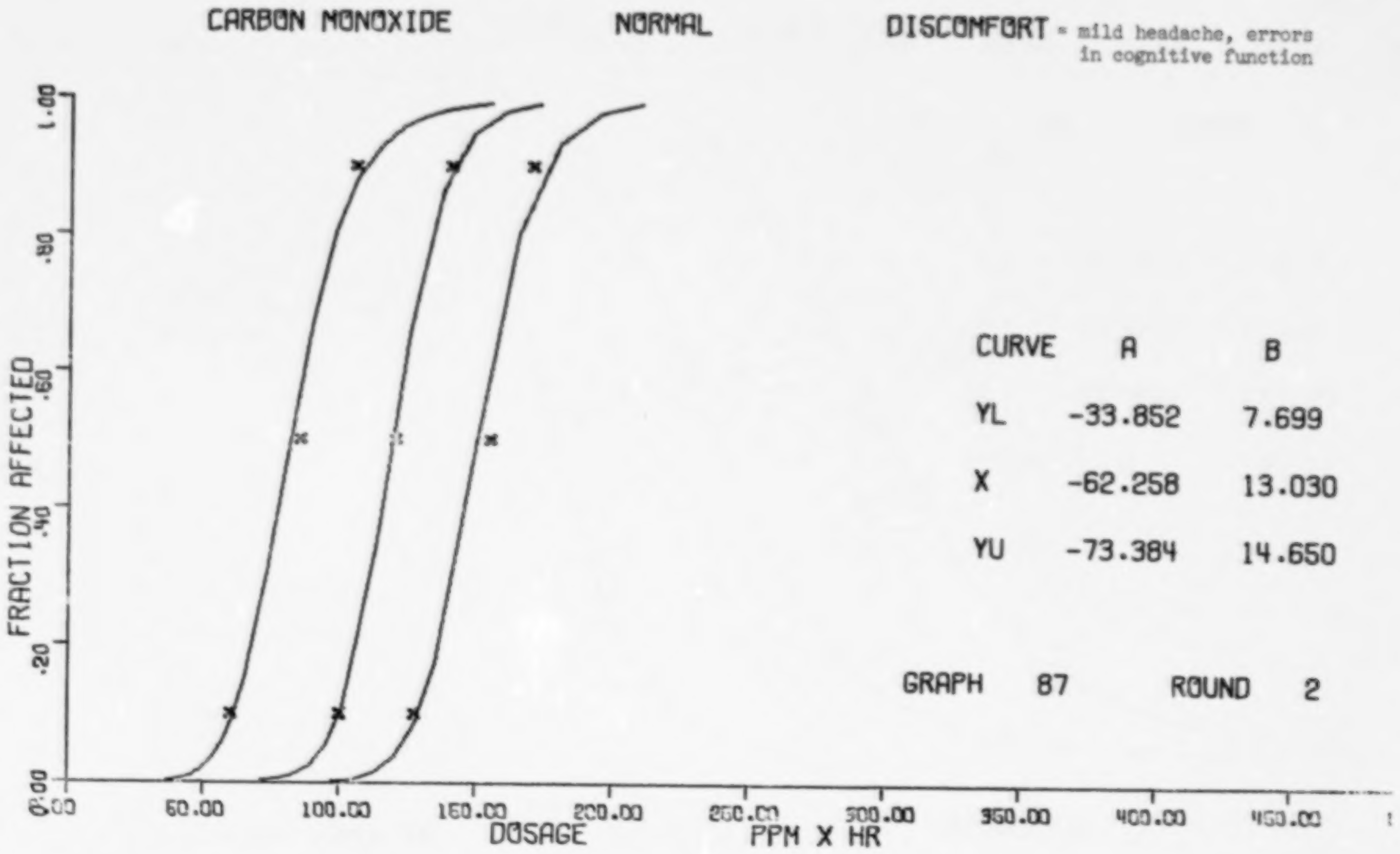
CURVE	A	B
YL	-1.358	5.136
X	-4.745	6.338
YU	-9.973	8.317

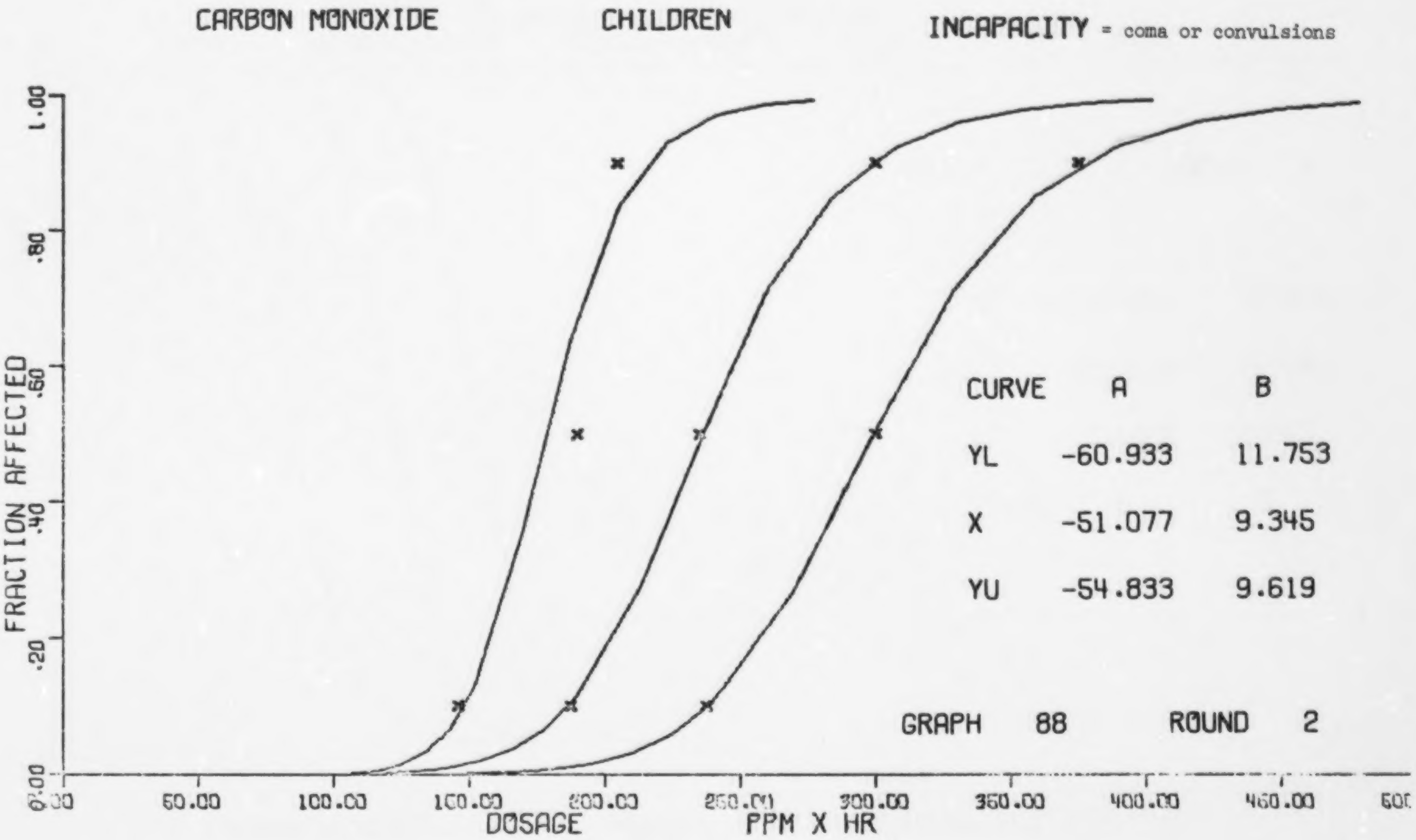
GRAPH 84 ROUND 2

CARBON MONOXIDE NORMAL INCAPACITY = coma or convulsions

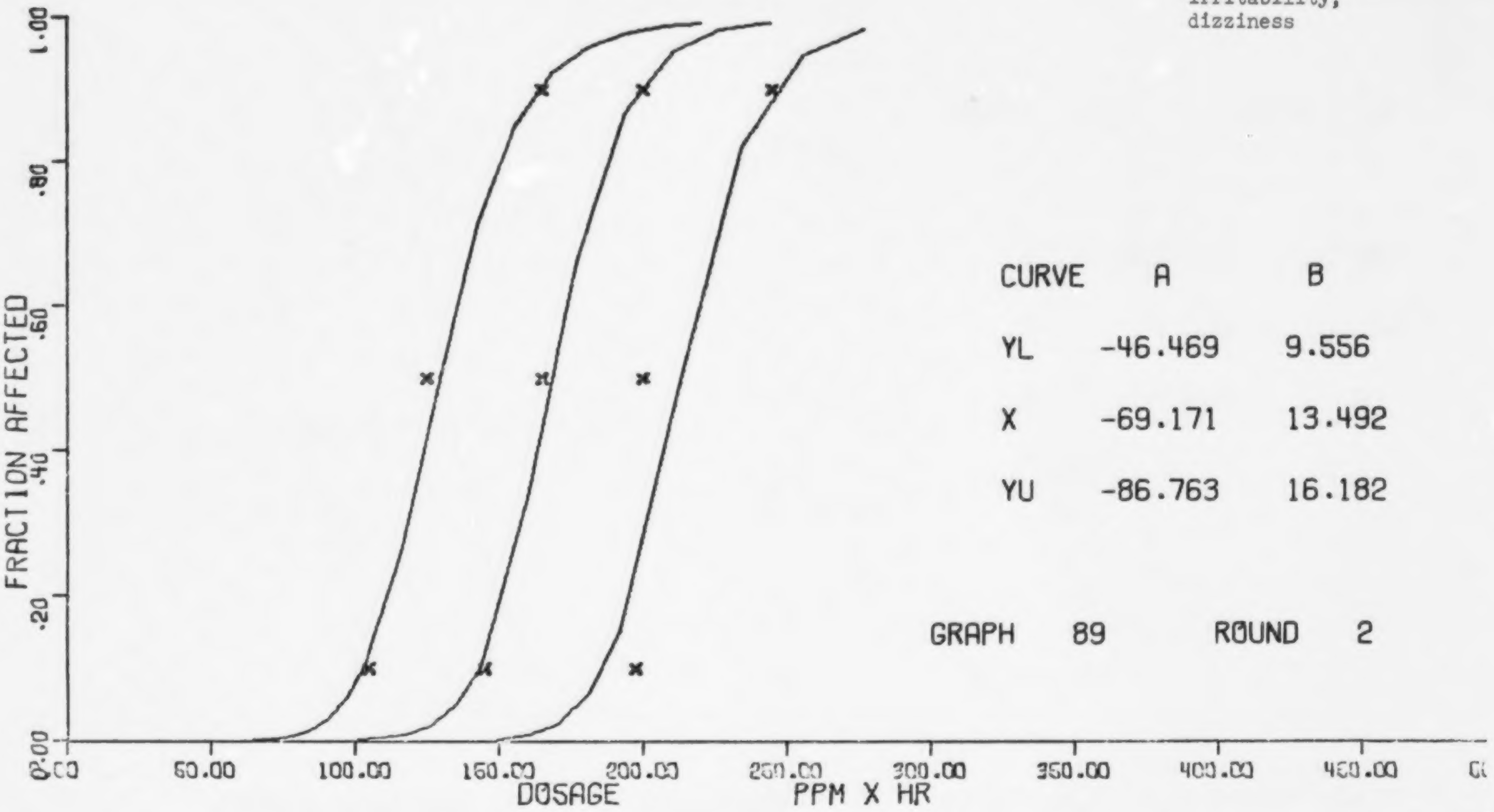



CARBON MONOXIDE
NORMAL
DISABILITY = throbbing headache, confusion, irritability, dizziness
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
60.00
100.00
160.00
200.00
260.00
300.00
360.00
400.00
460.00
60
DOSAGE
PPM X HR
CURVE A B
YL -62.702 12.525
X -66.298 12.670
YU -60.936 11.155
GRAPH 86
ROUND 2


CARBON MONOXIDE
NORMAL
DISCOMFORT = mild headache, errors in cognitive function
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
CURVE A B
YL -33.852 7.699
X -62.258 13.030
YU -73.384 14.650
GRAPH 87
ROUND 2


CARBON MONOXIDE
CHILDREN
INCAPACITY = coma or convulsions
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
DOSAGE
PPM X HR
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500
CURVE A B
YL -60.933 11.753
X -51.077 9.345
YU -54.833 9.619
GRAPH 88
ROUND 2

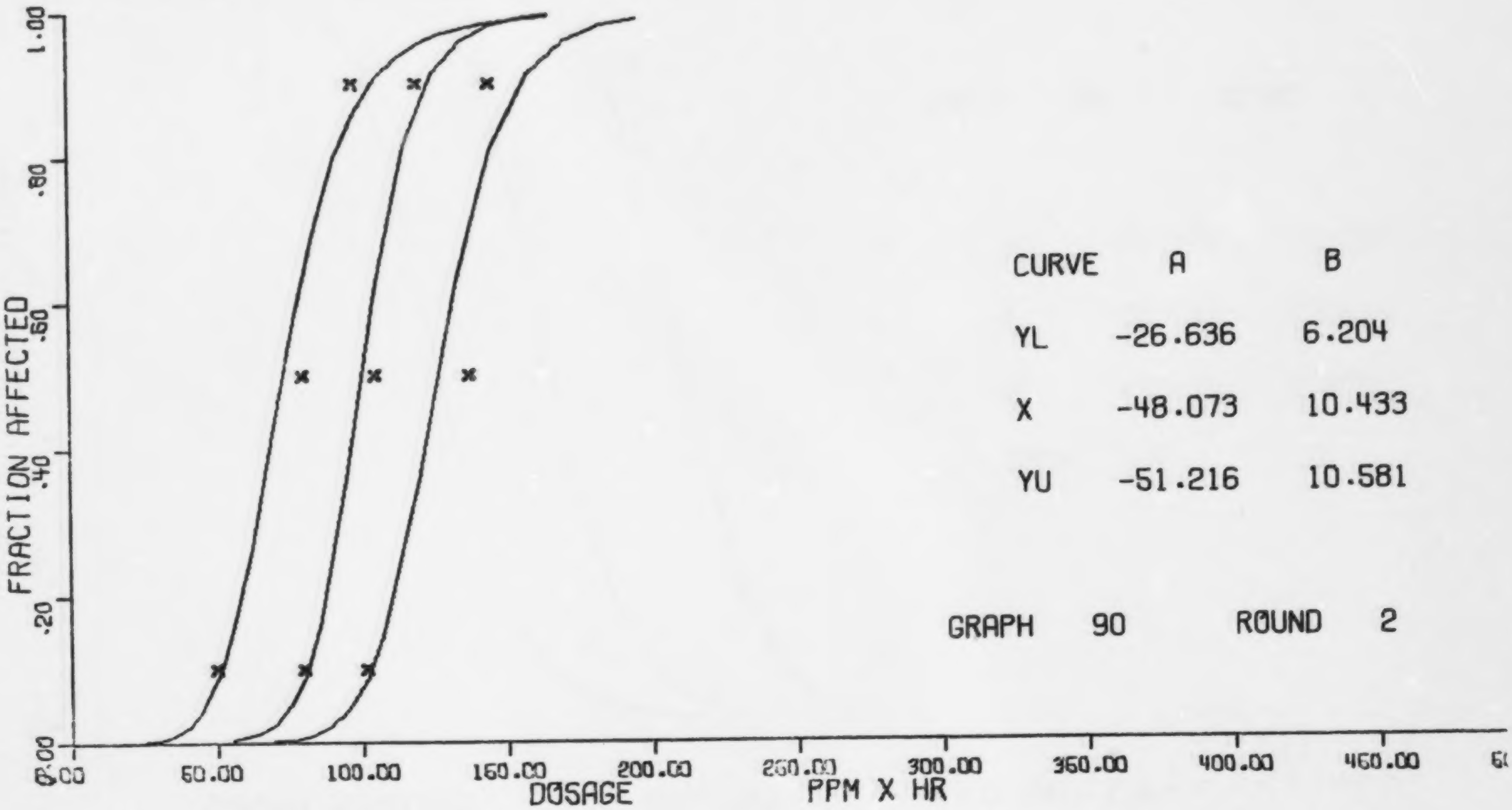
CARBON MONOXIDE CHILDREN **DISABILITY** = throbbing headache,
confusion,
irritability,
dizziness



CURVE	A	B
YL	-46.469	9.556
X	-69.171	13.492
YU	-86.763	16.182

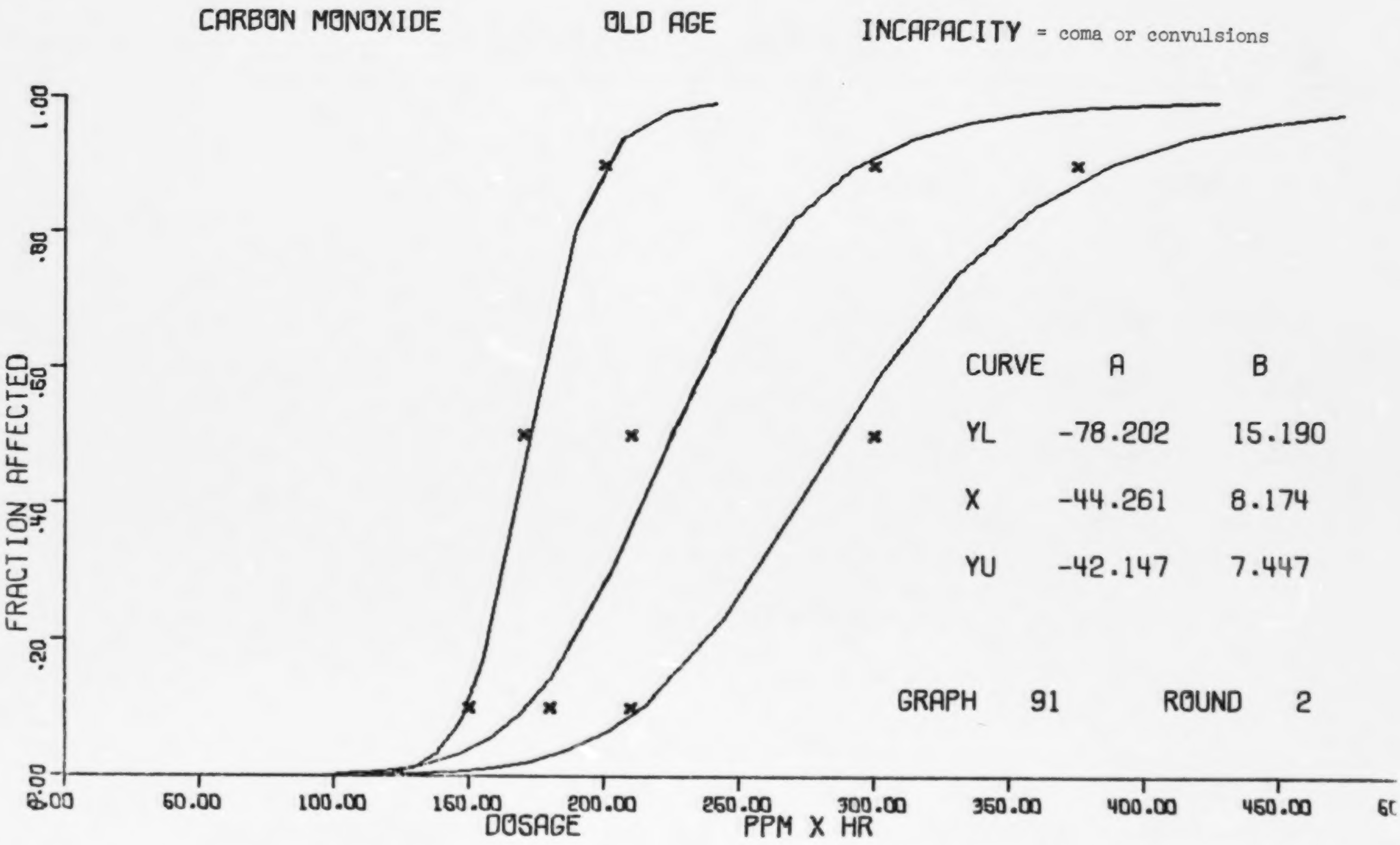
GRAPH 89 ROUND 2

CARBON MONOXIDE CHILDREN DISCOMFORT = mild headache, errors in cognitive function

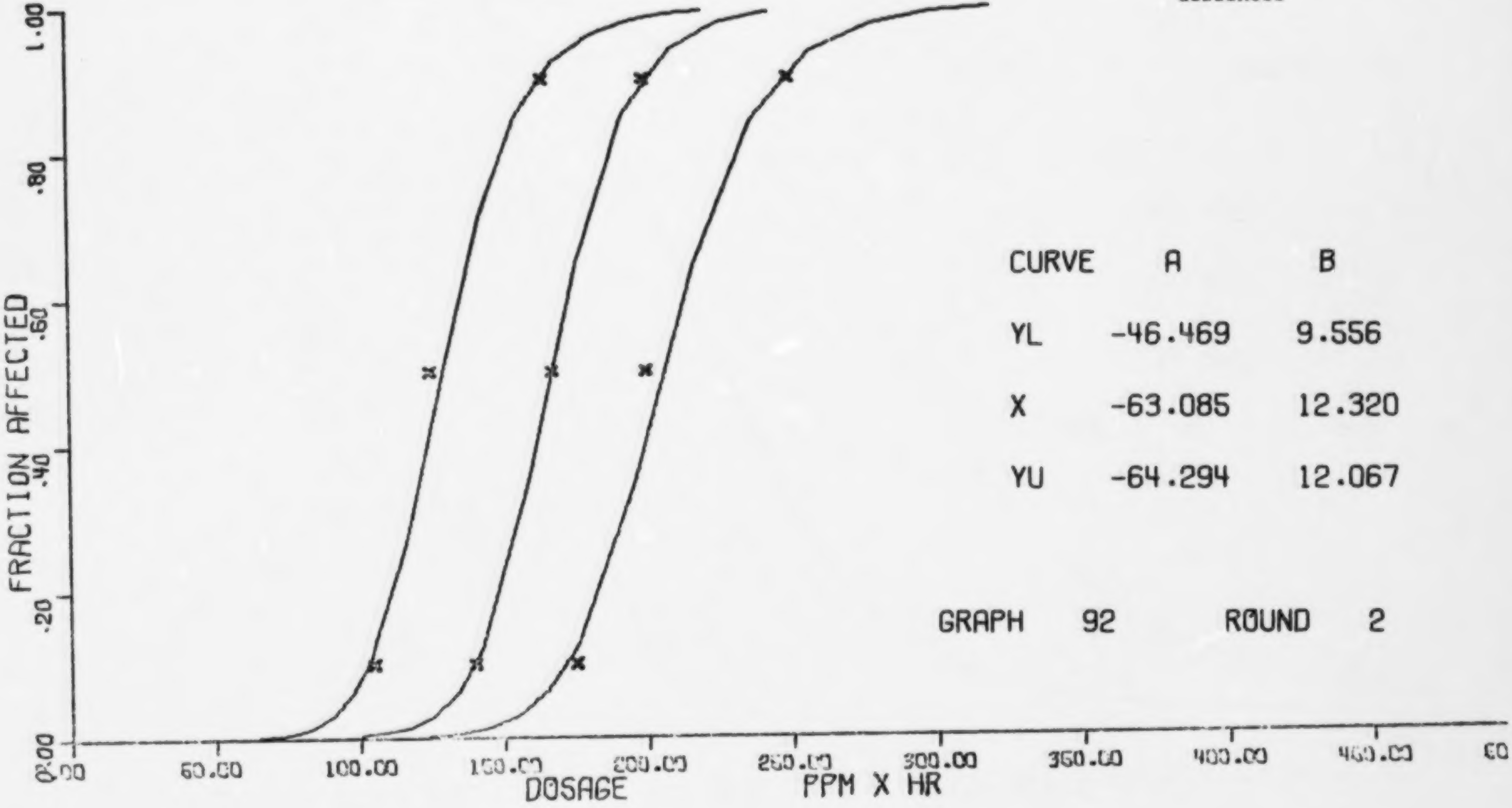


CURVE	A	B
YL	-26.636	6.204
X	-48.073	10.433
YU	-51.216	10.581

GRAPH 90 ROUND 2


CARBON MONOXIDE
OLD AGE
INCAPACITY = coma or convulsions
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
6
DOSAGE
PPM X HR
CURVE A B
YL -78.202 15.190
X -44.261 8.174
YU -42.147 7.447
GRAPH 91
ROUND 2

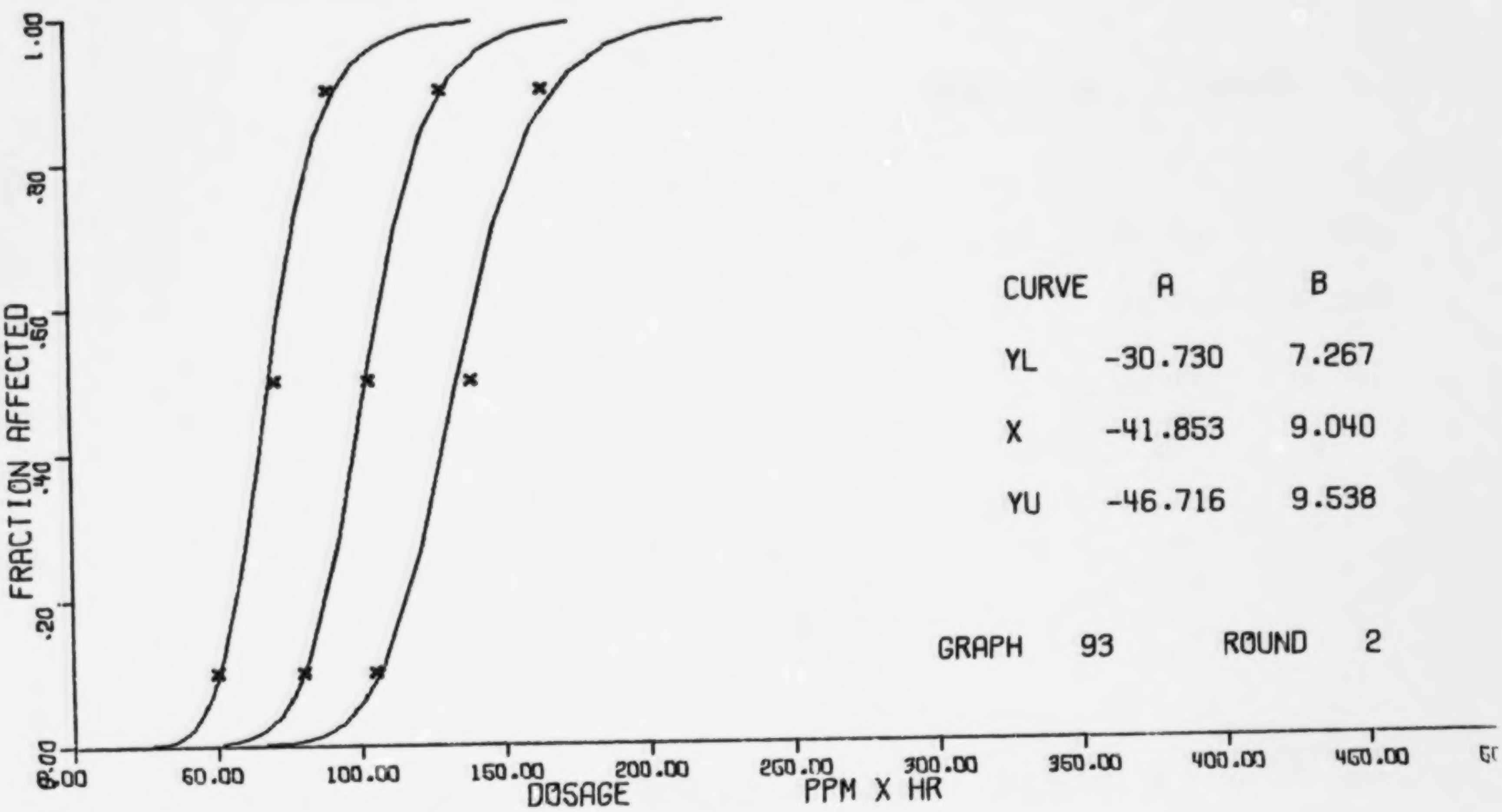
CARBON MONOXIDE OLD AGE **DISABILITY** = throbbing headache,
confusion,
irritability,
dizziness



CURVE	A	B
YL	-46.469	9.556
X	-63.085	12.320
YU	-64.294	12.067

GRAPH 92 ROUND 2

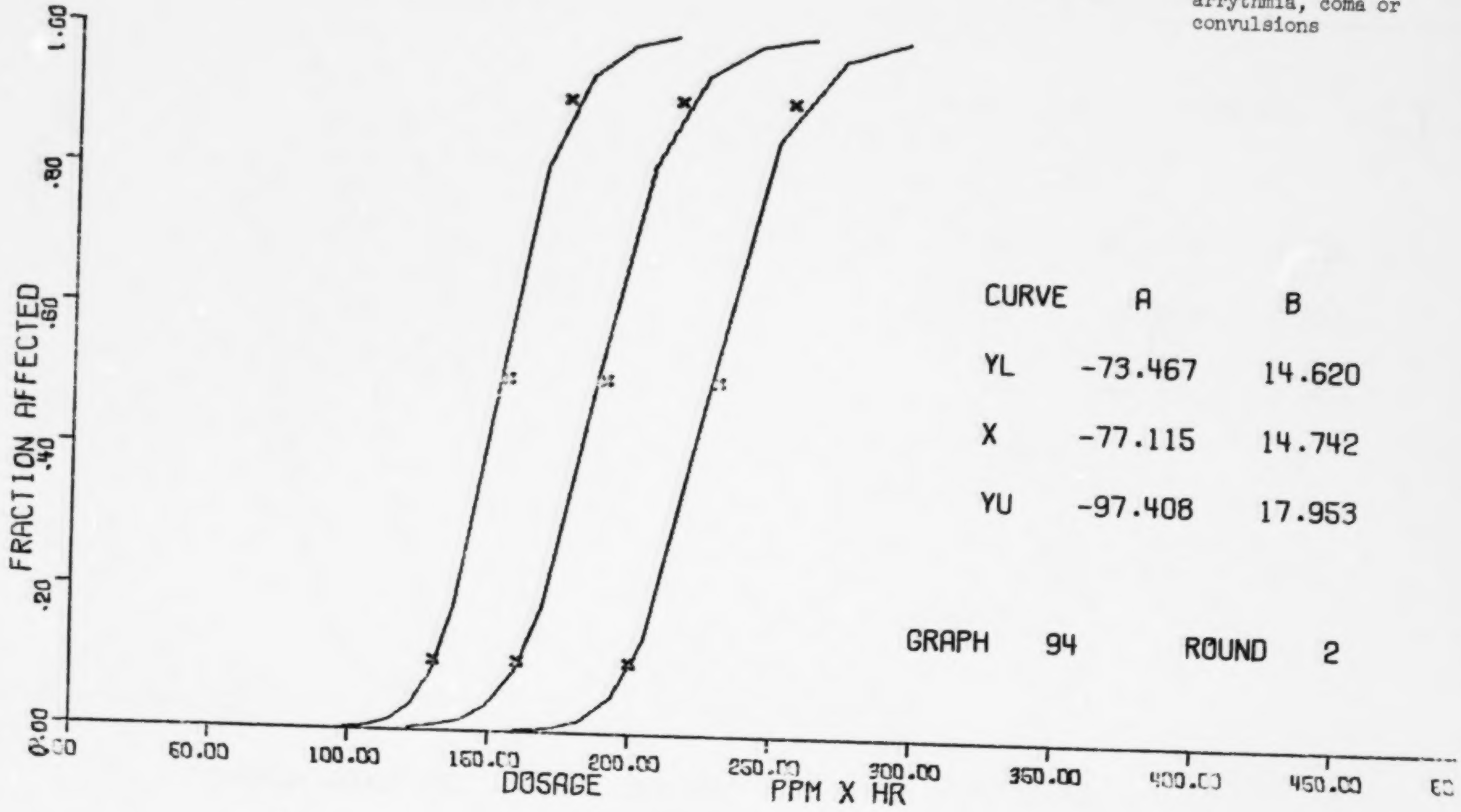
CARBON MONOXIDE **OLD AGE** **DISCOMFORT** = mild headache, errors in cognitive function



CURVE	A	B
YL	-30.730	7.267
X	-41.853	9.040
YU	-46.716	9.538

GRAPH 93 ROUND 2

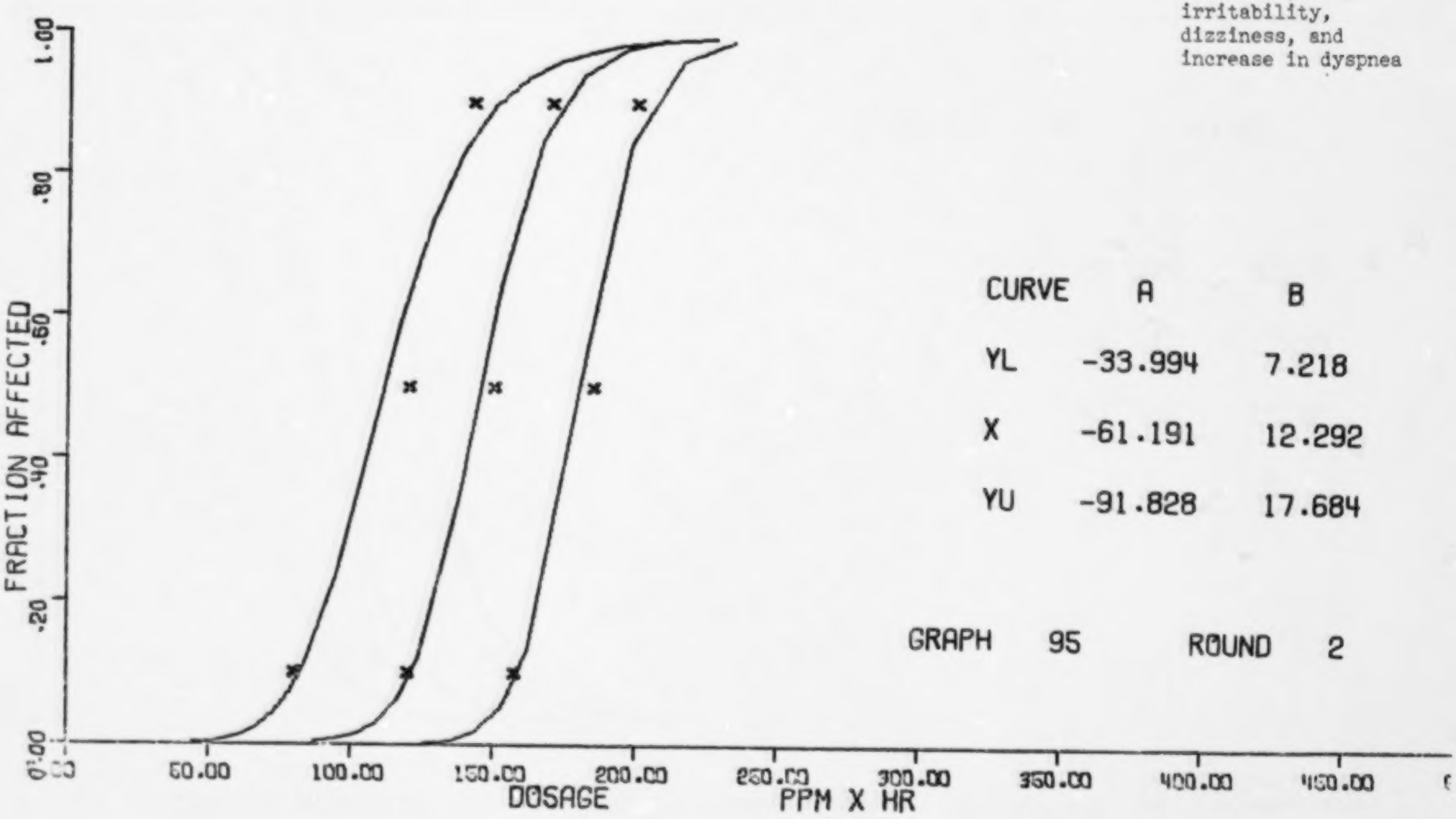
CARBON MONOXIDE HEART COND. MILD INCAPACITY = angina pectoris, arrythmia, coma or convulsions



CURVE	A	B
YL	-73.467	14.620
X	-77.115	14.742
YU	-97.408	17.953

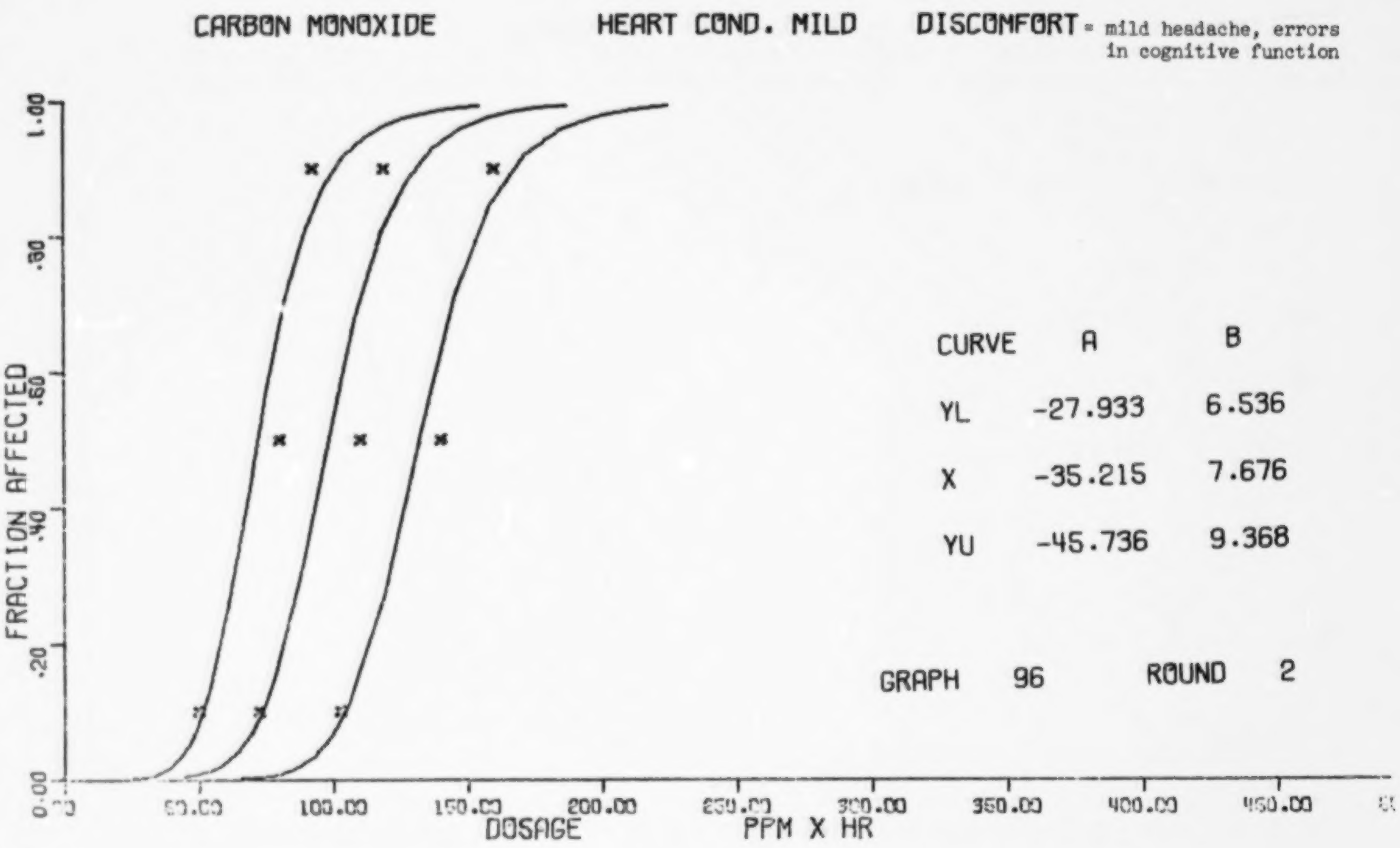
GRAPH 94 ROUND 2

CARBON MONOXIDE HEART COND. MILD DISABILITY = throbbing headache, confusion, irritability, dizziness, and increase in dyspnea

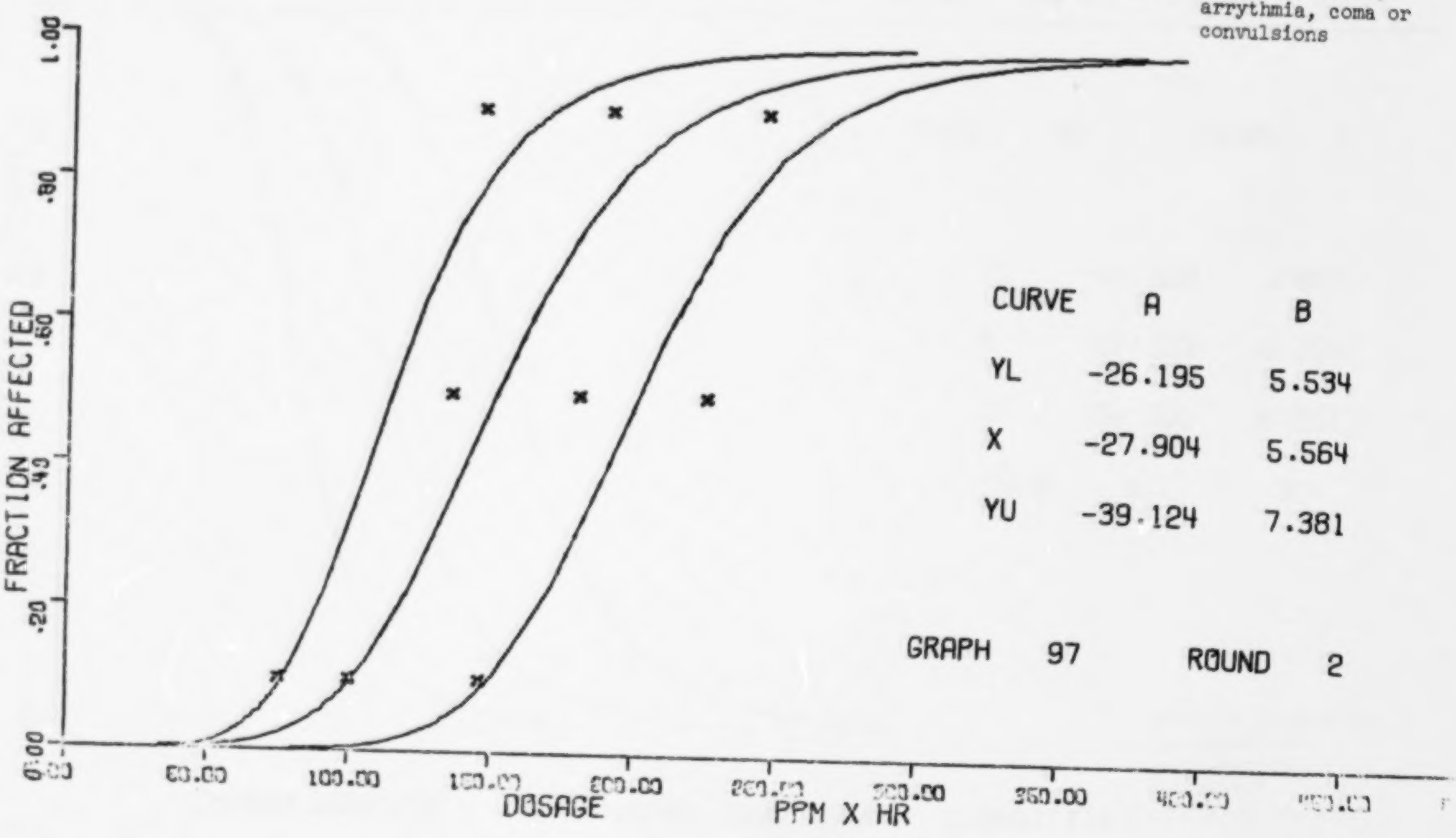


CURVE	A	B
YL	-33.994	7.218
X	-61.191	12.292
YU	-91.828	17.684

GRAPH 95 ROUND 2

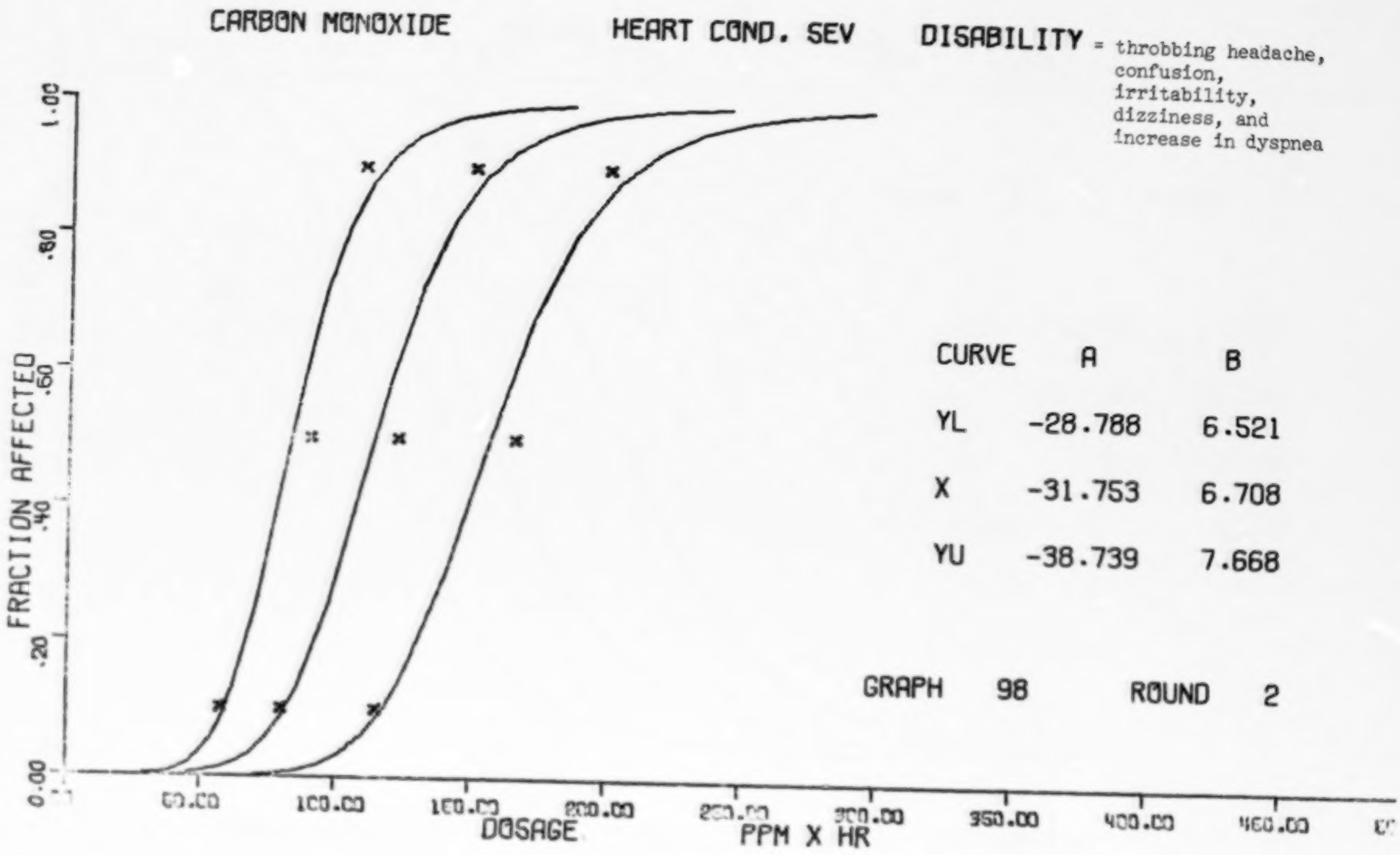

CARBON MONOXIDE
HEART COND. MILD
DISCOMFORT = mild headache, errors in cognitive function
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
DOSAGE
PPM X HR
CURVE A B
YL -27.933 6.536
X -35.215 7.676
YU -45.736 9.368
GRAPH 96
ROUND 2

CARBON MONOXIDE HEART COND. SEV INCAPACITY = angina pectoris, arrythmia, coma or convulsions



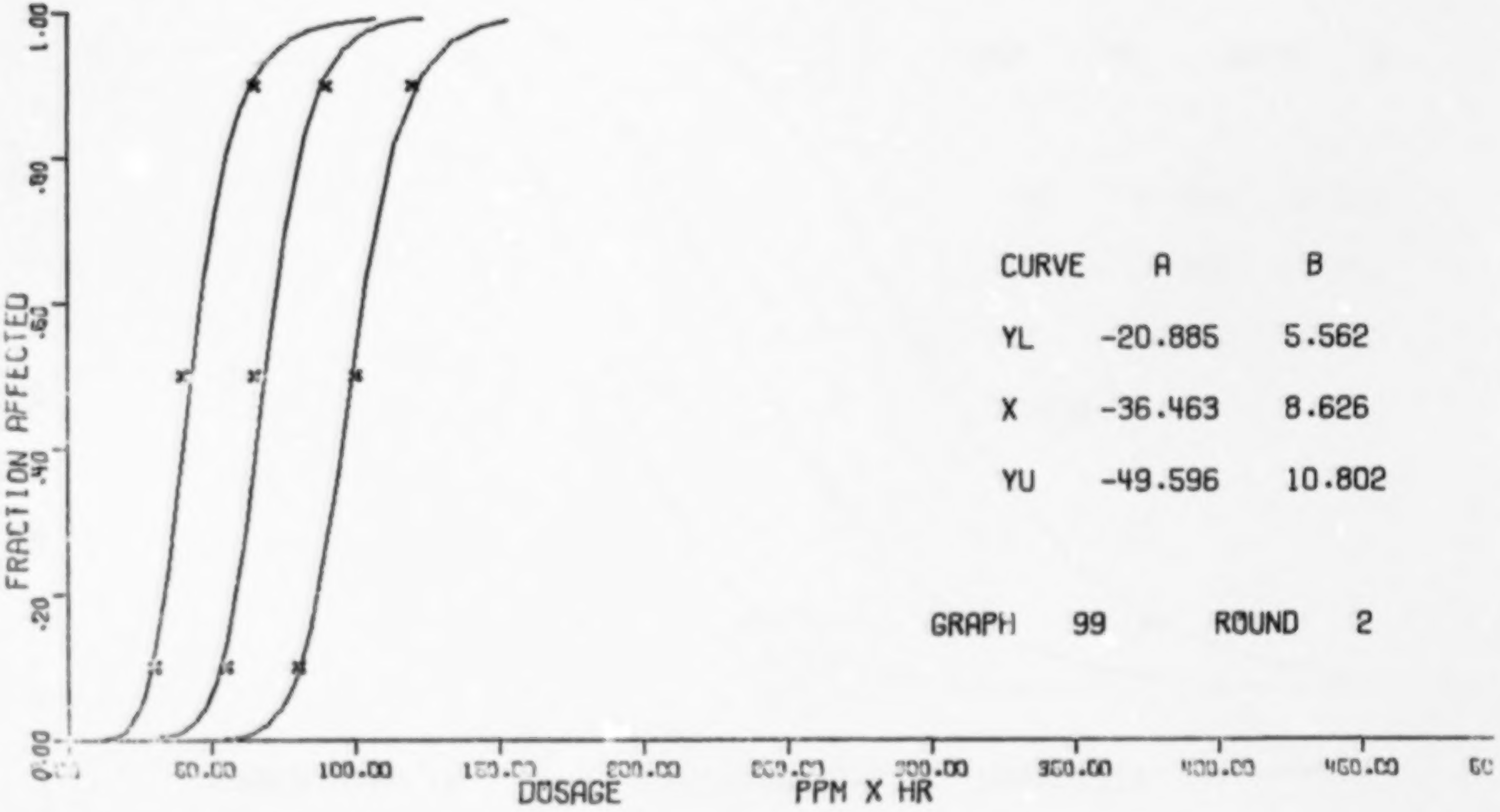
CURVE	A	B
YL	-26.195	5.534
X	-27.904	5.564
YU	-39.124	7.381

GRAPH 97 ROUND 2



CURVE	A	B
YL	-28.788	6.521
X	-31.753	6.708
YU	-38.739	7.668

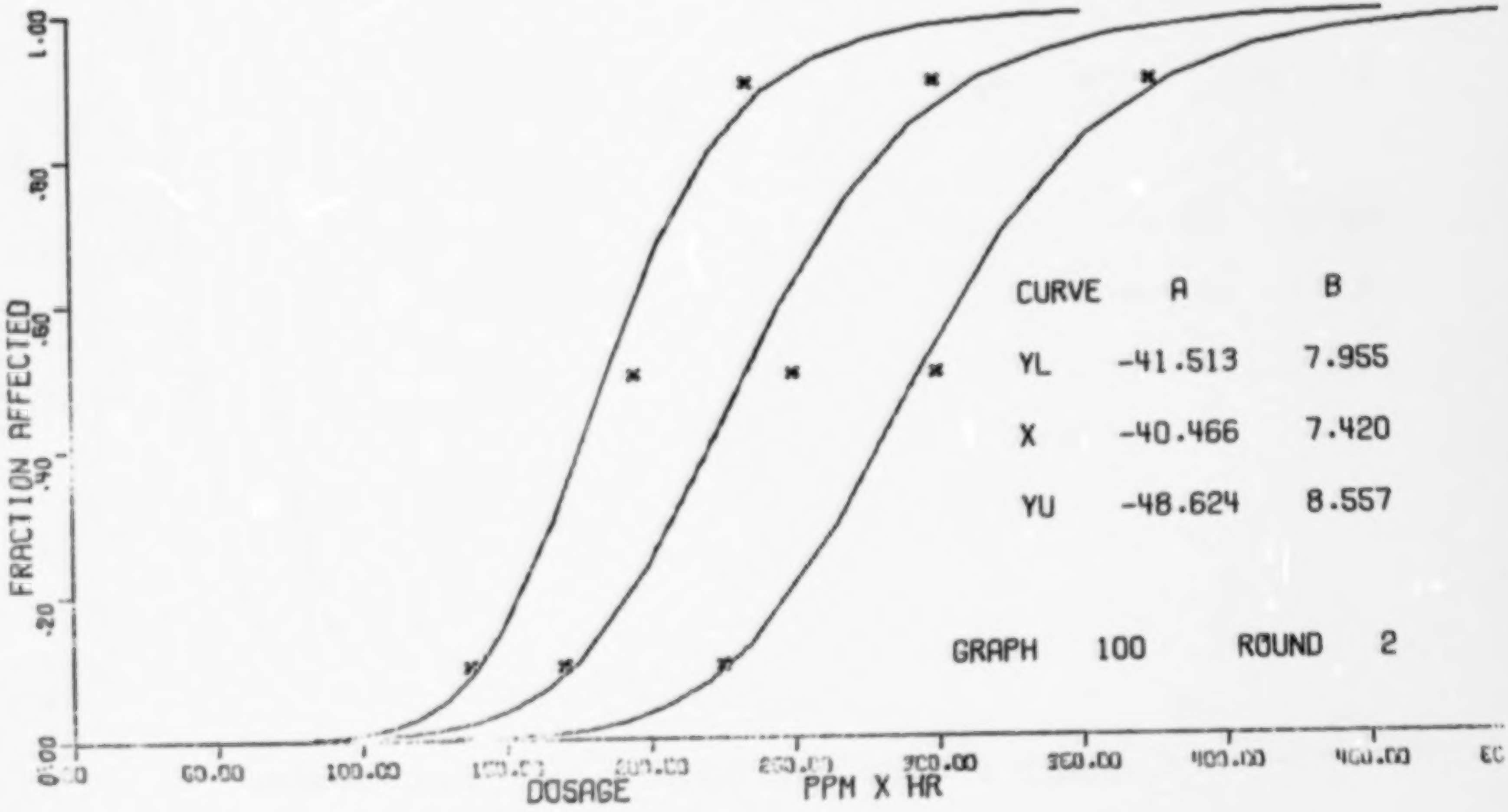
CARBON MONOXIDE HEART COND. SEV DISCOMFORT = mild headache, errors in cognitive function

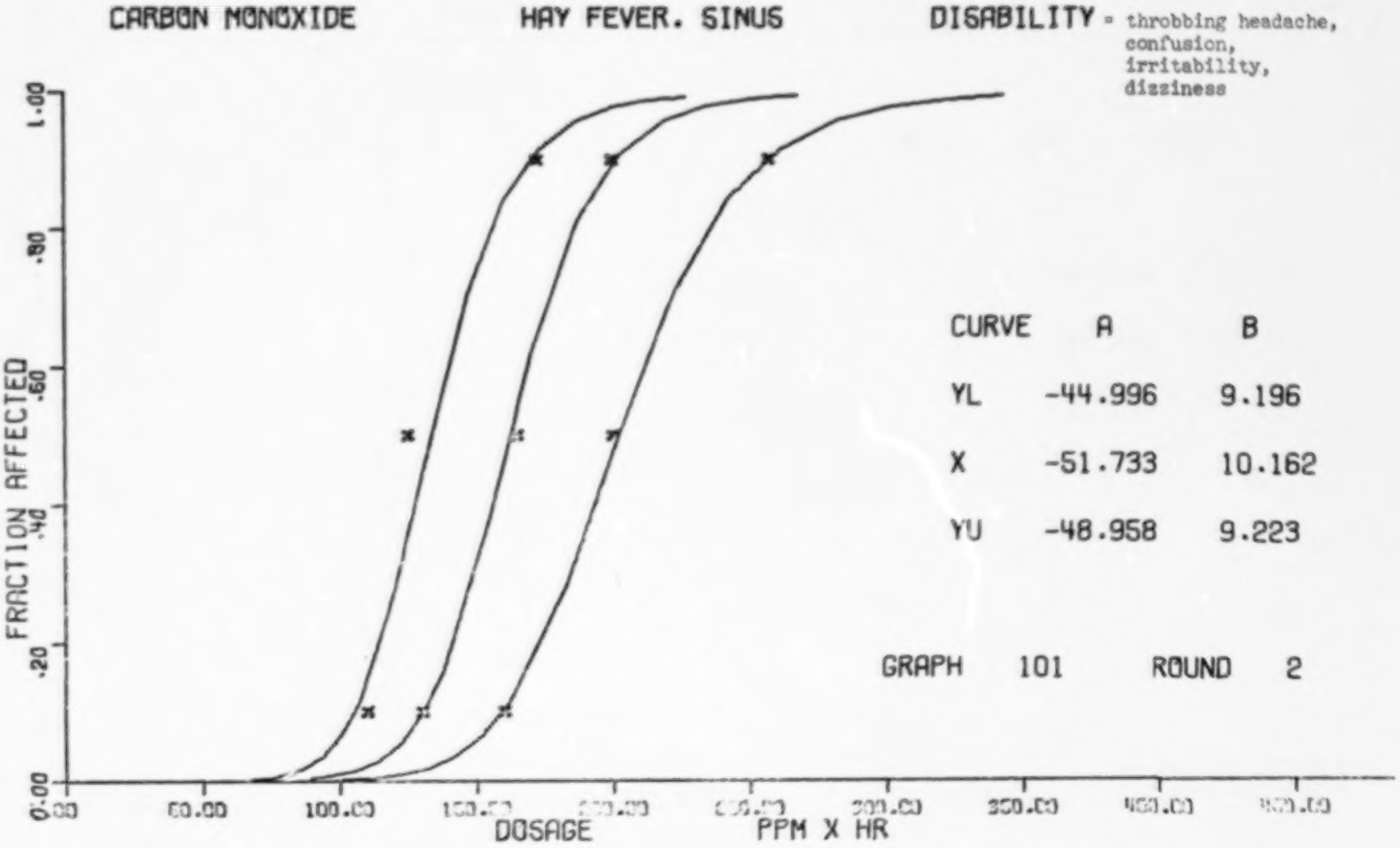


CURVE	A	B
YL	-20.885	5.562
X	-36.463	8.626
YU	-49.596	10.802

GRAPH 99 ROUND 2

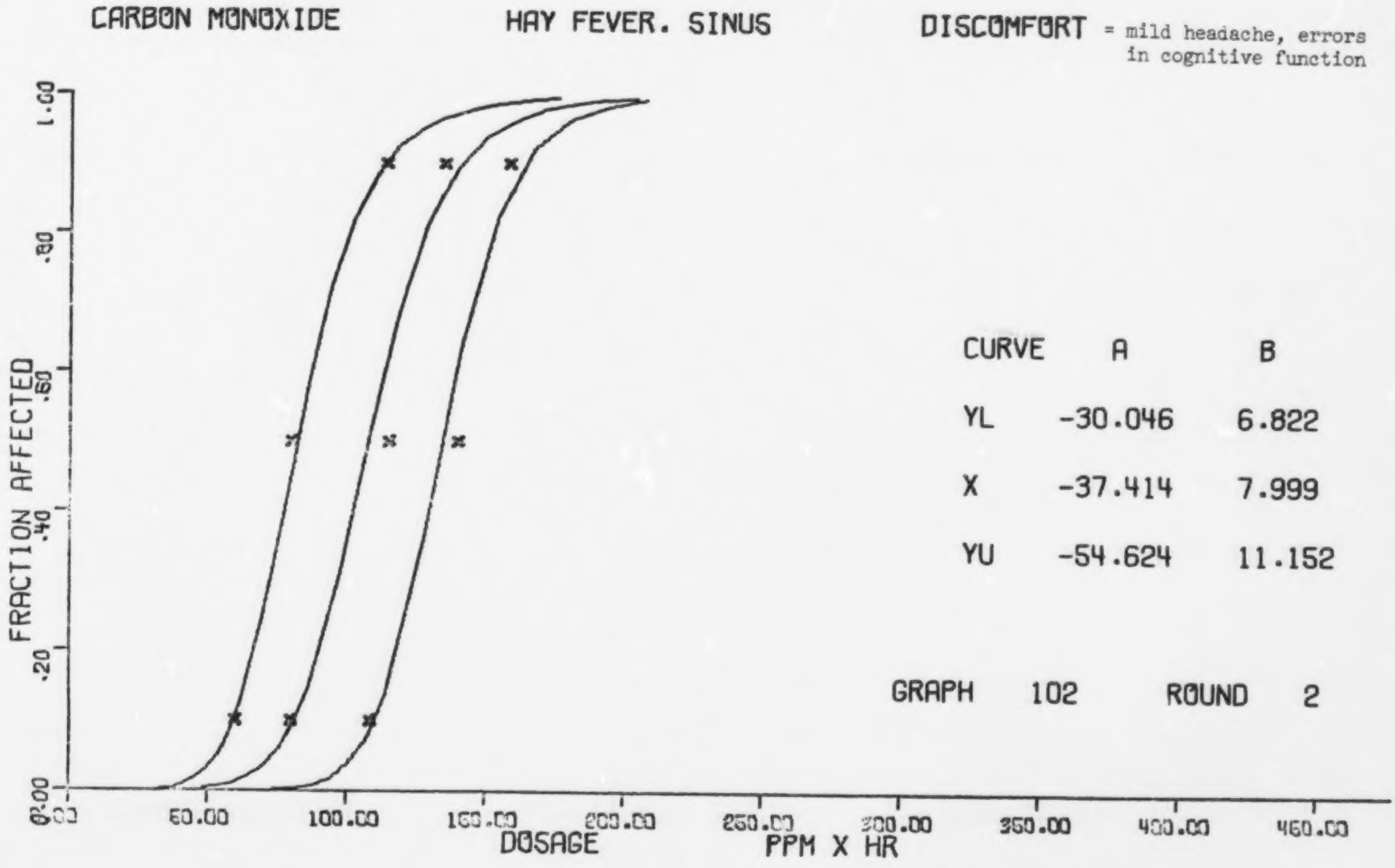
CARBON MONOXIDE HAY FEVER. SINUS INCAPACITY = coma or convulsions



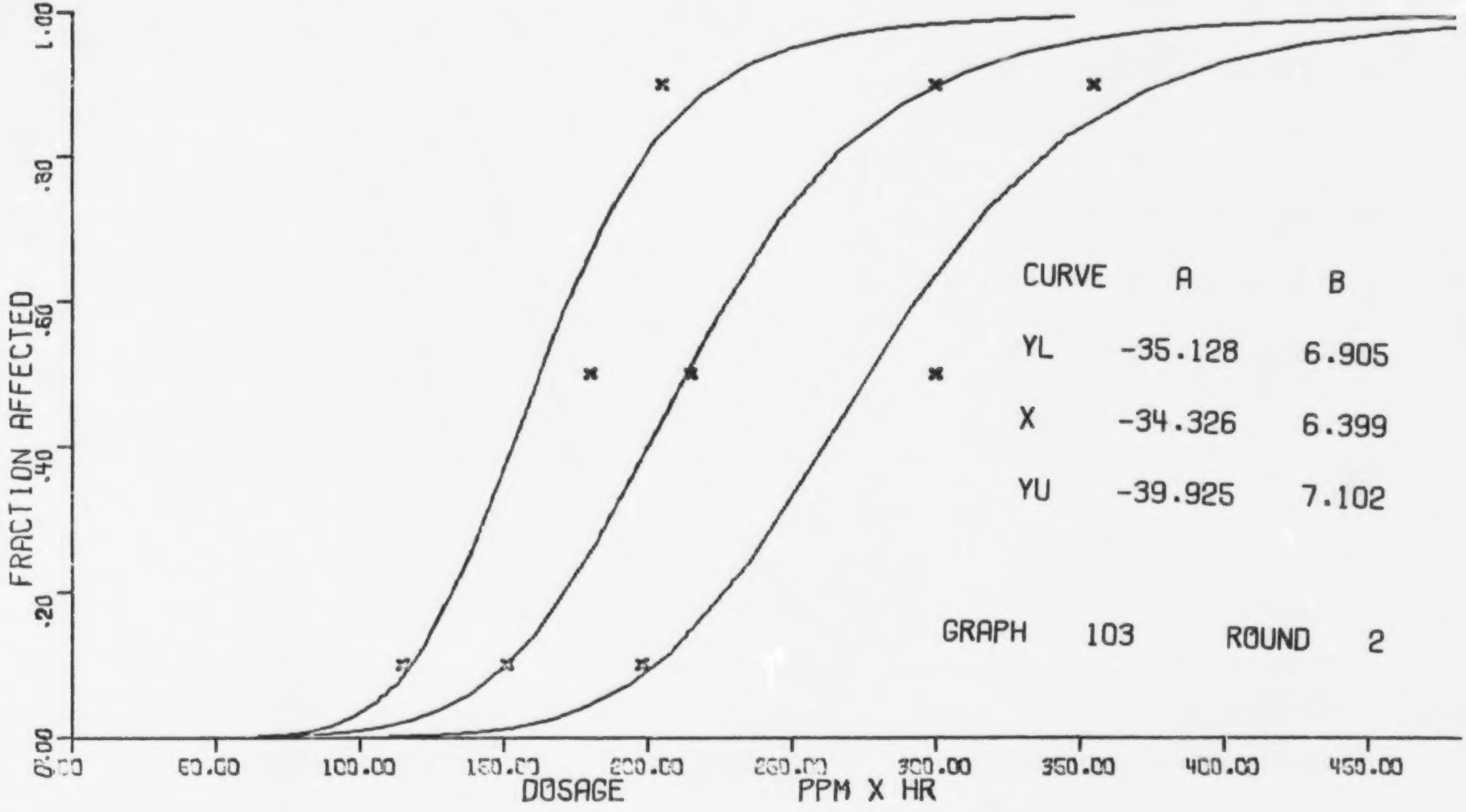


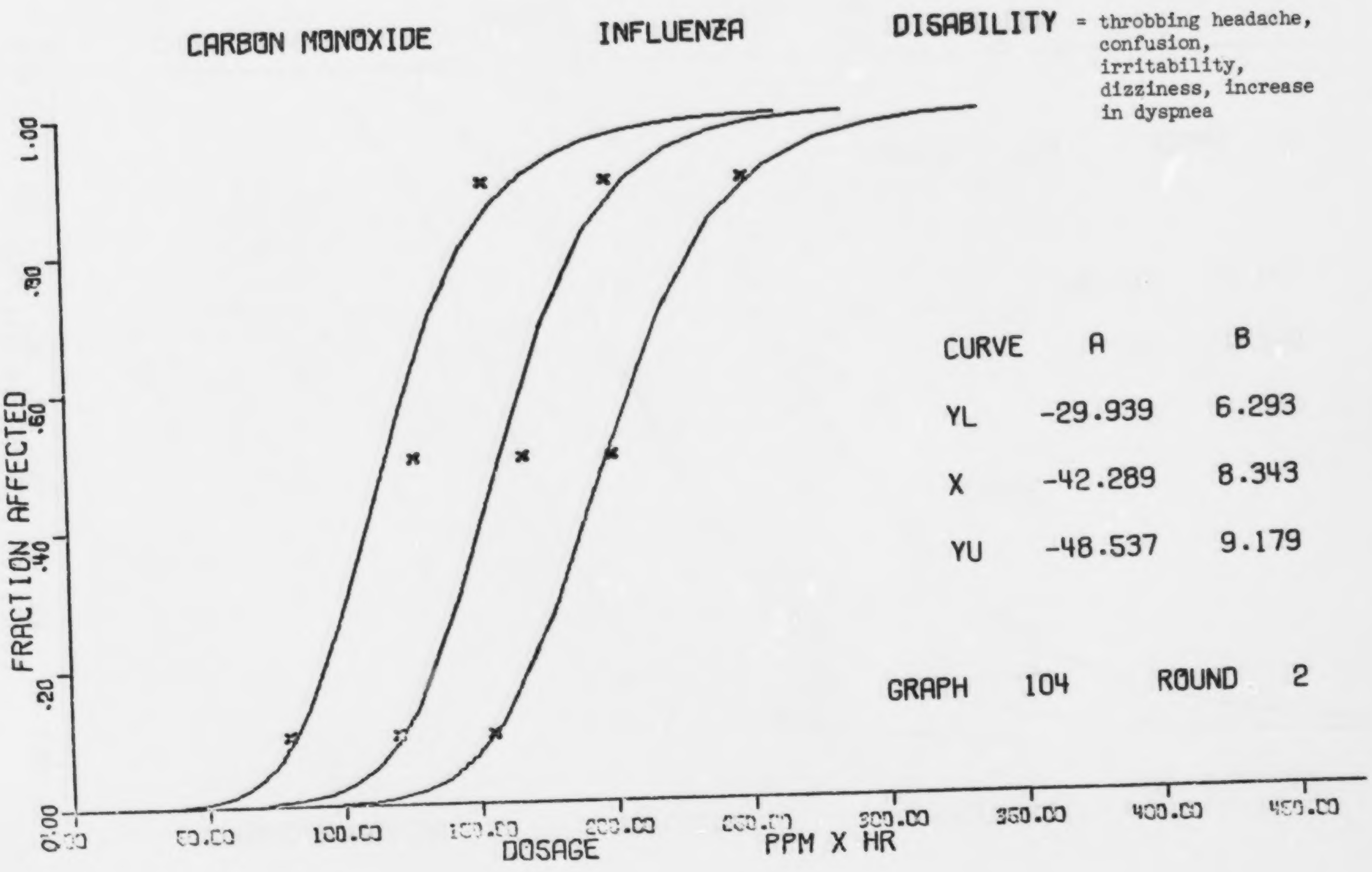
CURVE	A	B
YL	-44.996	9.196
X	-51.733	10.162
YU	-48.958	9.223

GRAPH 101 ROUND 2

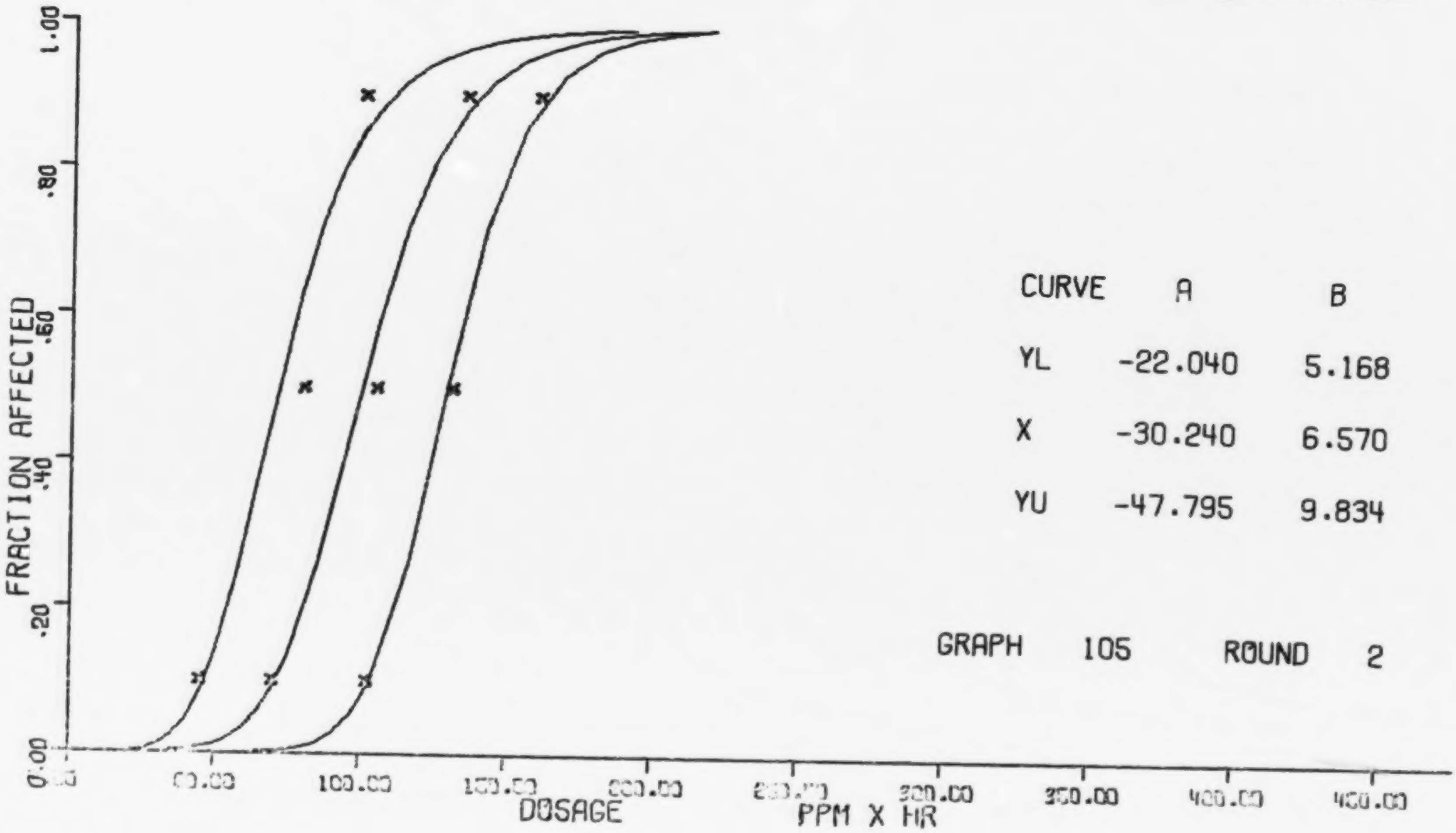

CARBON MONOXIDE
HAY FEVER. SINUS
DISCOMFORT = mild headache, errors in cognitive function
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
DOSAGE
PPM X HR
CURVE A B
YL -30.046 6.822
X -37.414 7.999
YU -54.624 11.152
GRAPH 102
ROUND 2

CARBON MONOXIDE INFLUENZA INCAPACITY = respiratory failure, coma, convulsions




CARBON MONOXIDE
INFLUENZA
DISABILITY = throbbing headache, confusion, irritability, dizziness, increase in dyspnea
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
DOSAGE
PPM X HR
CURVE A B
YL -29.939 6.293
X -42.289 8.343
YU -48.537 9.179
GRAPH 104
ROUND 2

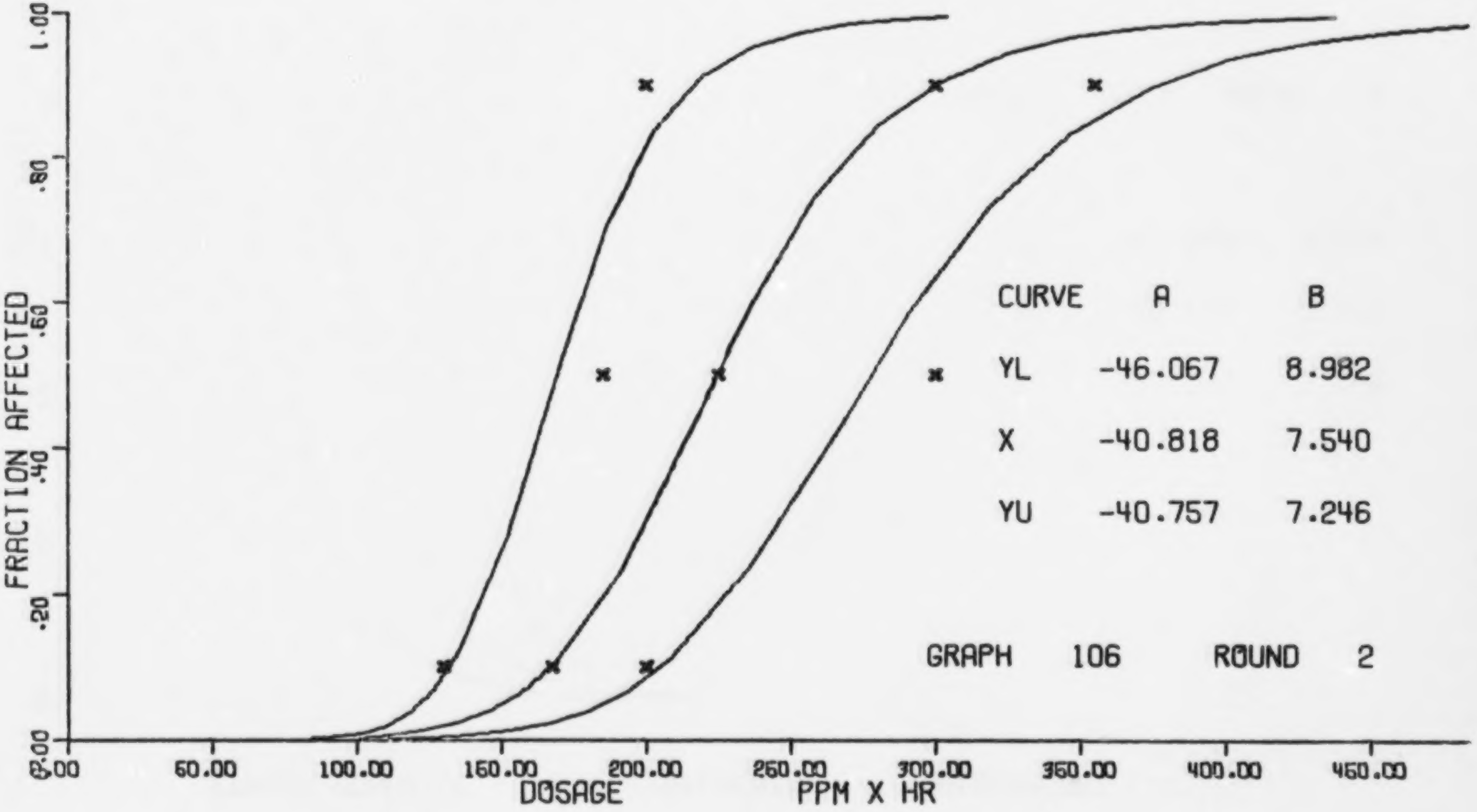
CARBON MONOXIDE INFLUENZA **DISCOMFORT** = mild headache, errors in cognitive function



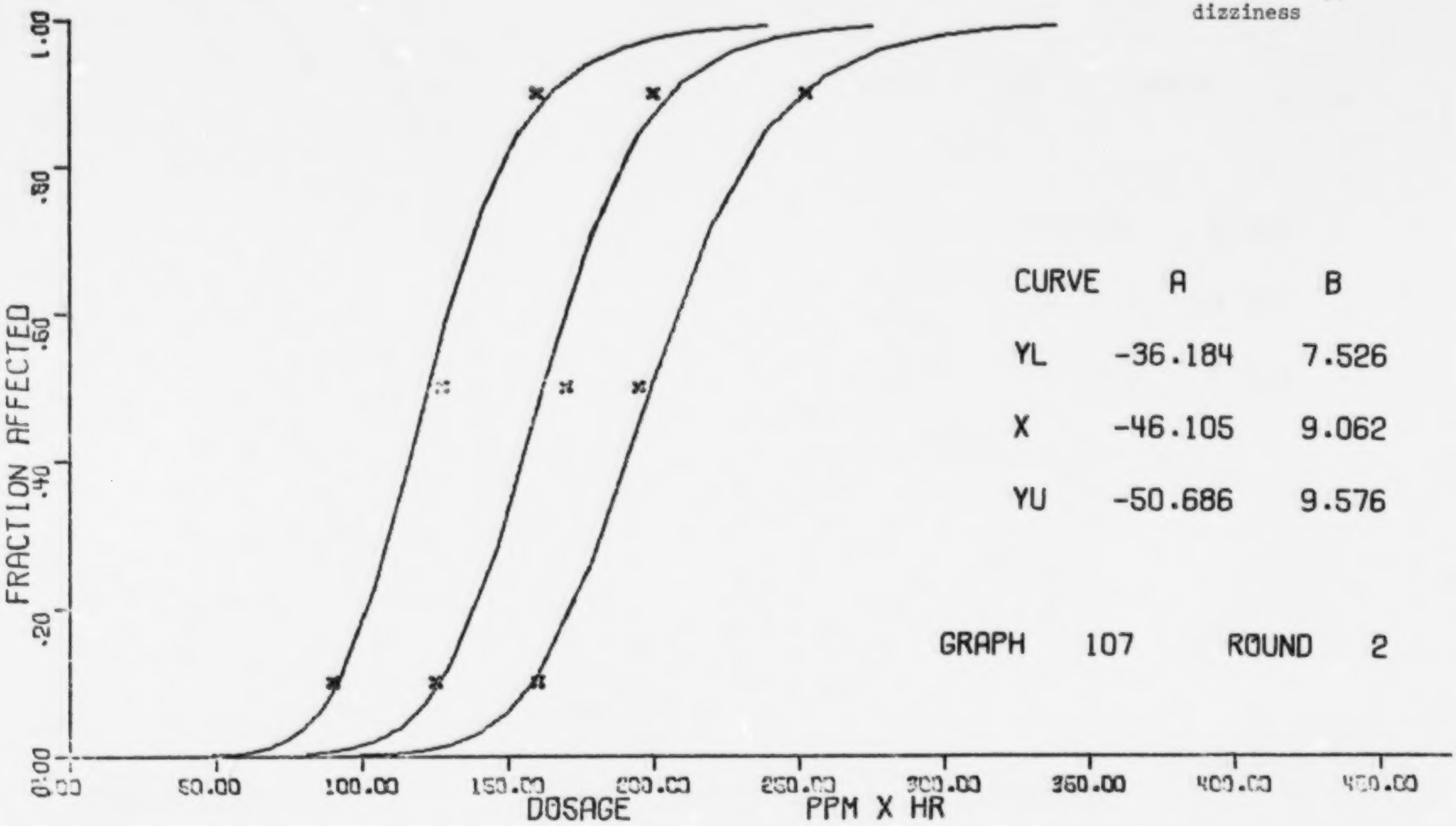
CURVE	A	B
YL	-22.040	5.168
X	-30.240	6.570
YU	-47.795	9.834

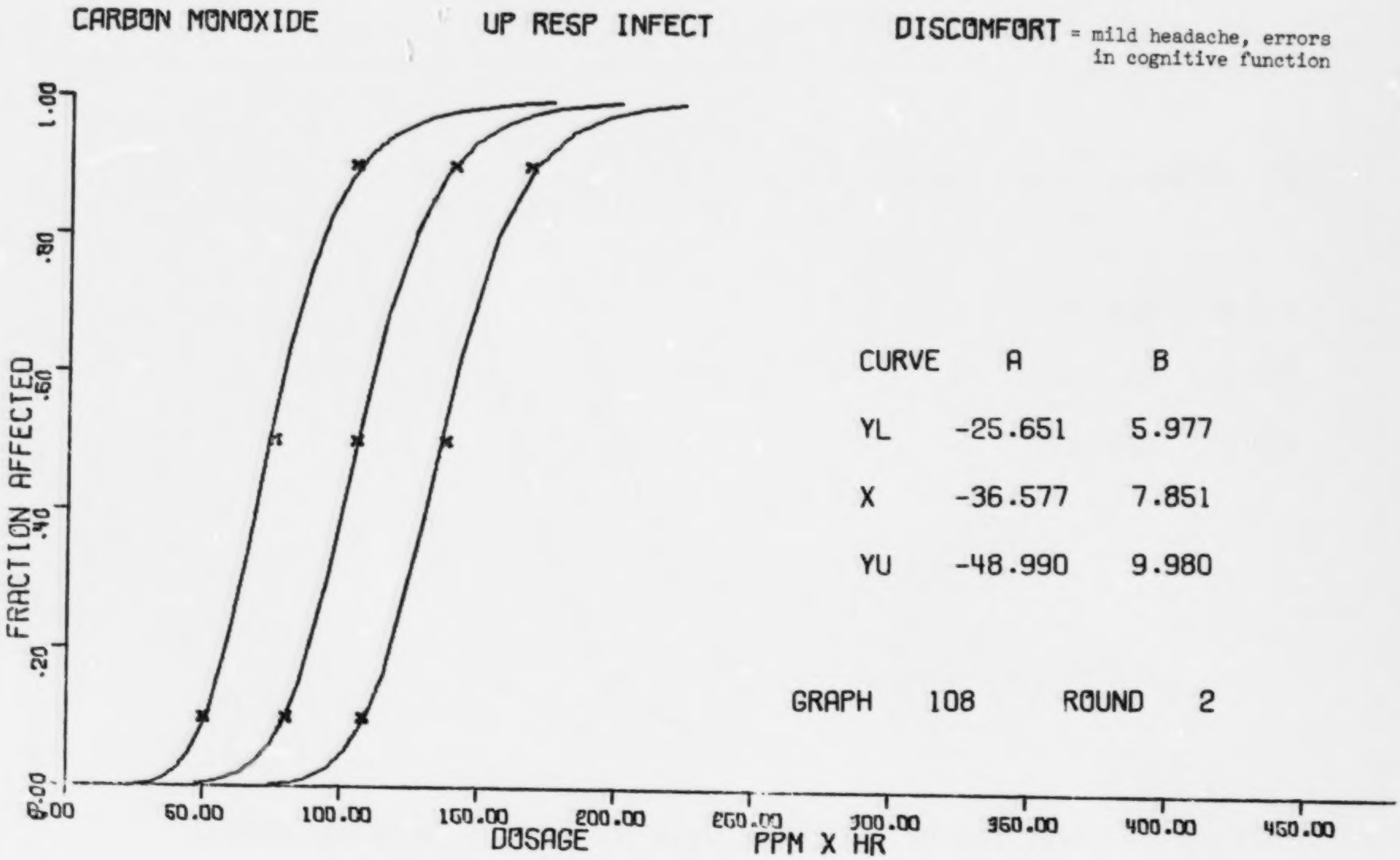
GRAPH 105 ROUND 2

CARBON MONOXIDE UP RESP INFECT INCAPACITY = coma or convulsions

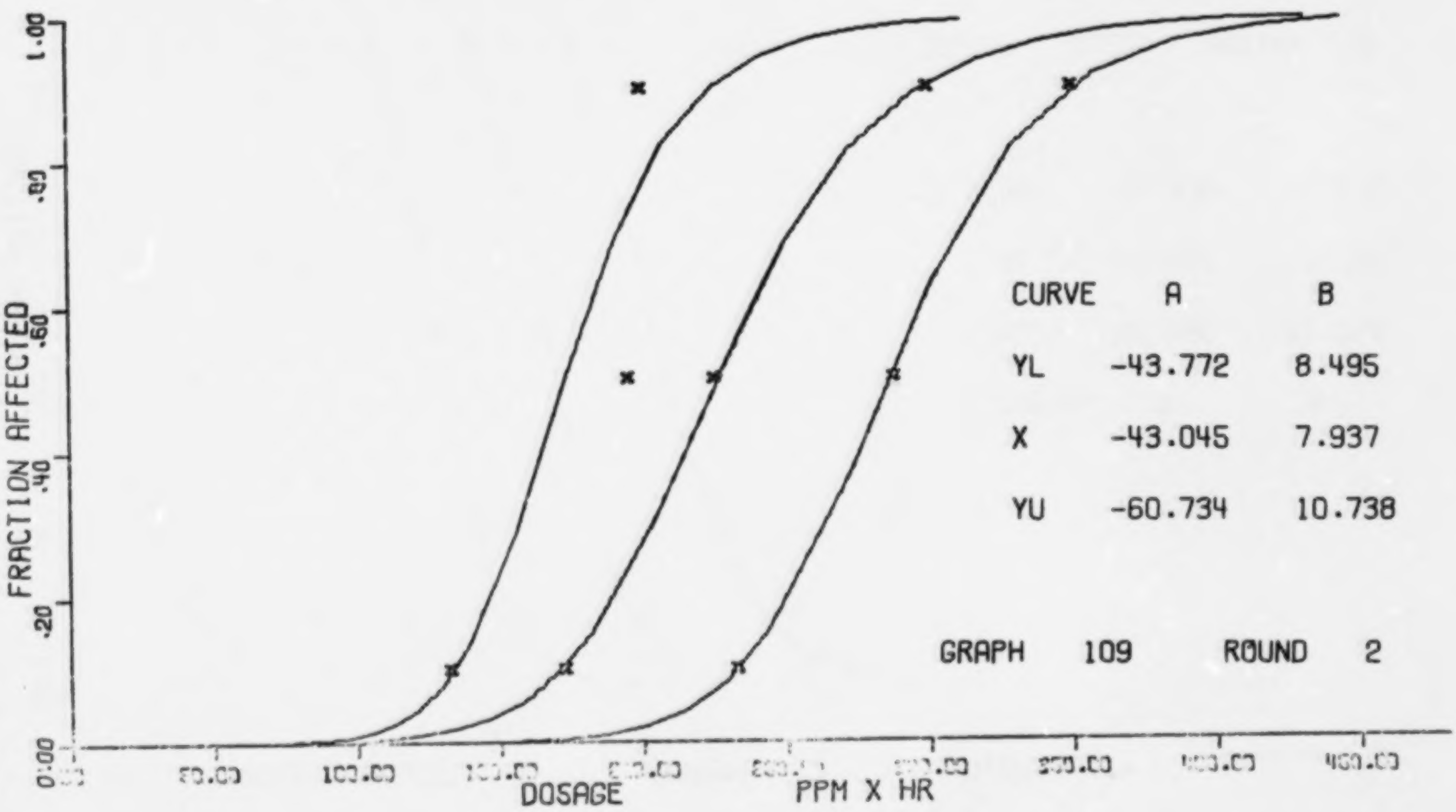


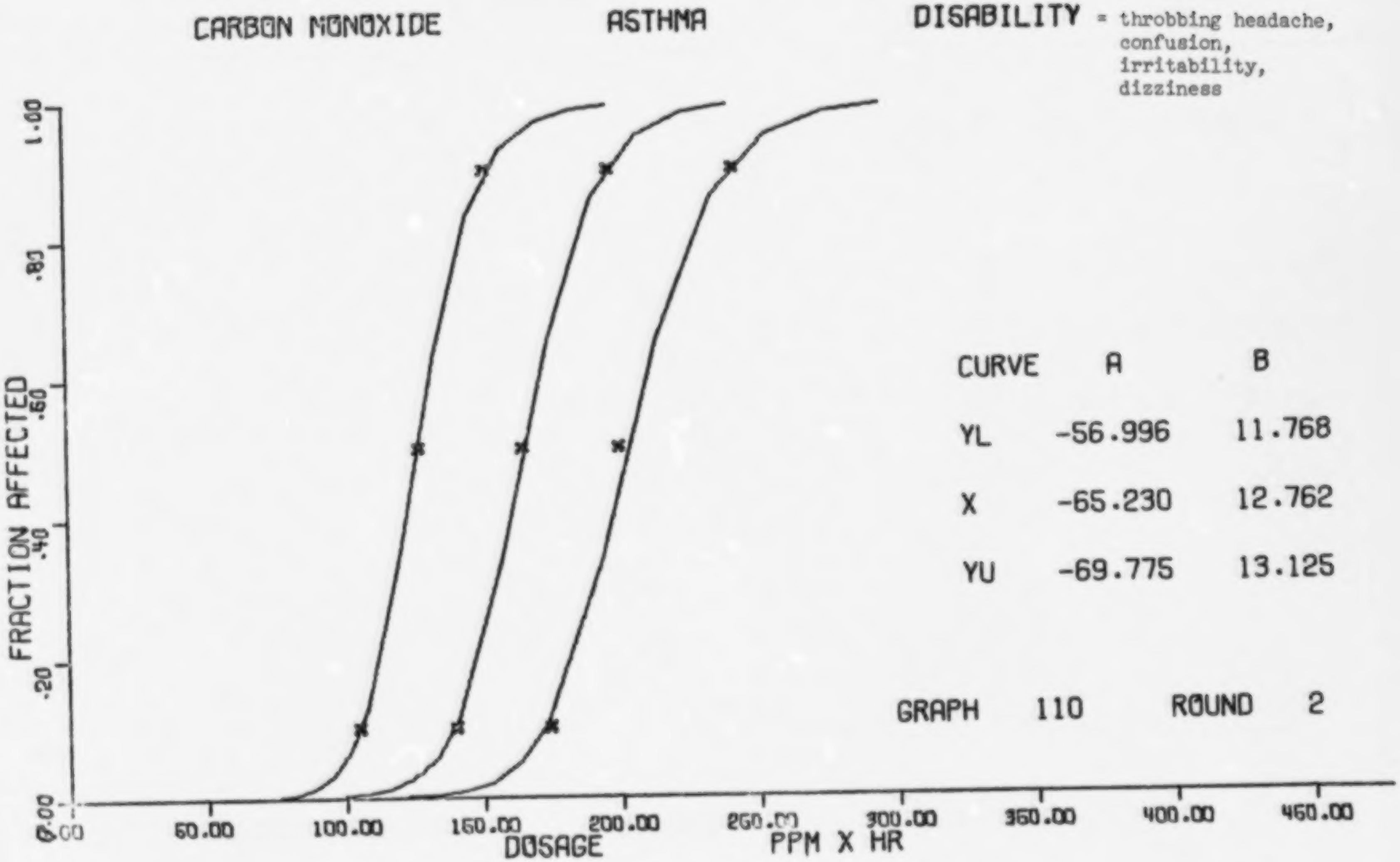
CARBON MONOXIDE UP RESP INFECT **DISABILITY** = throbbing headache,
confusion,
irritability,
dizziness



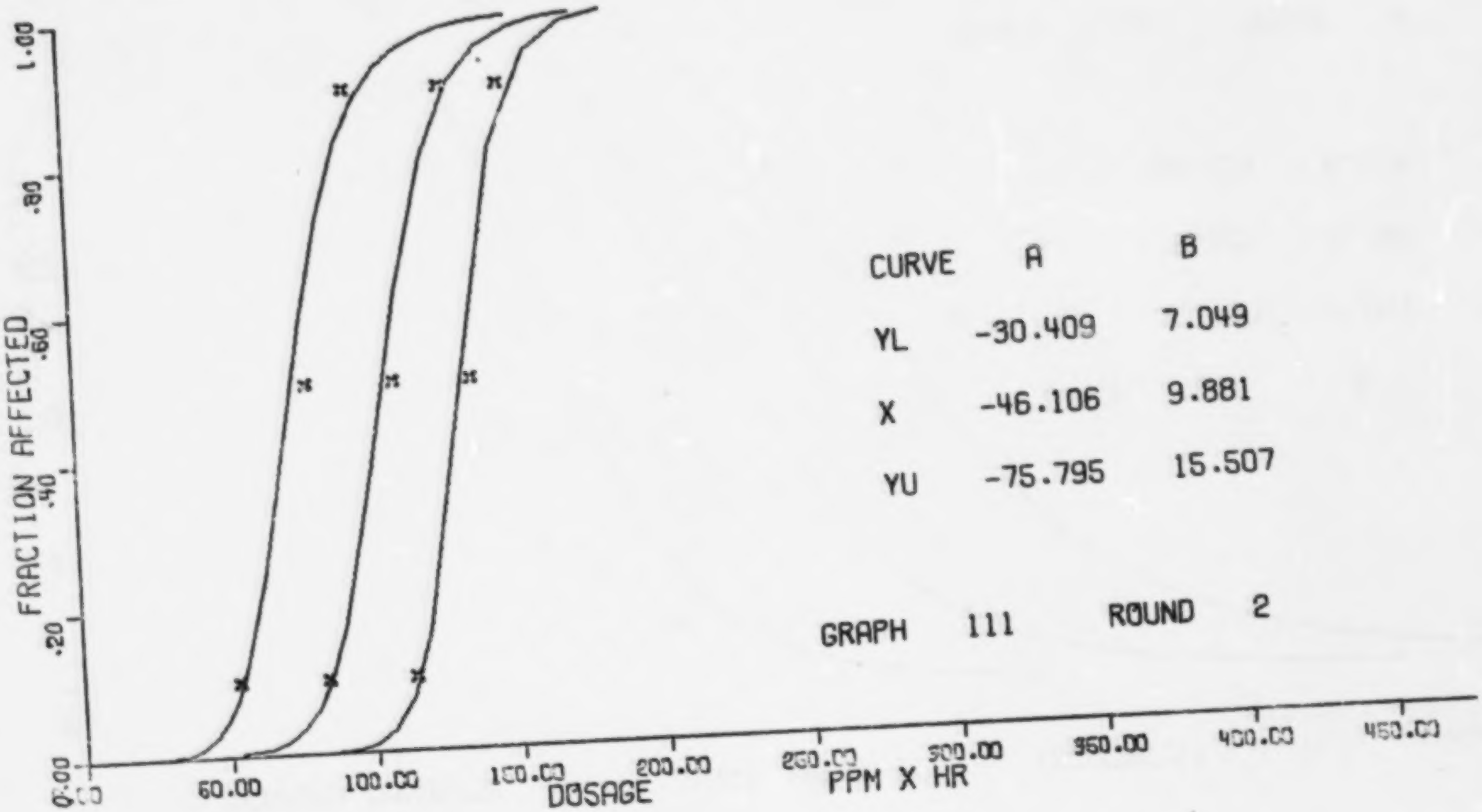

CARBON MONOXIDE
UP RESP INFECT
DISCOMFORT = mild headache, errors in cognitive function
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
DOSAGE
PPM X HR
CURVE A B
YL -25.651 5.977
X -36.577 7.851
YU -48.990 9.980
GRAPH 108
ROUND 2

CARBON MONOXIDE ASTHMA INCAPACITY = asthmatic attack, coma or convulsions




CARBON MONOXIDE
ASTHMA
DISABILITY = throbbing headache,
confusion,
irritability,
dizziness
CURVE A B
YL -56.996 11.768
X -65.230 12.762
YU -69.775 13.125
GRAPH 110 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
60.00
100.00
160.00
200.00
260.00
300.00
360.00
400.00
460.00
DOSAGE PPM X HR

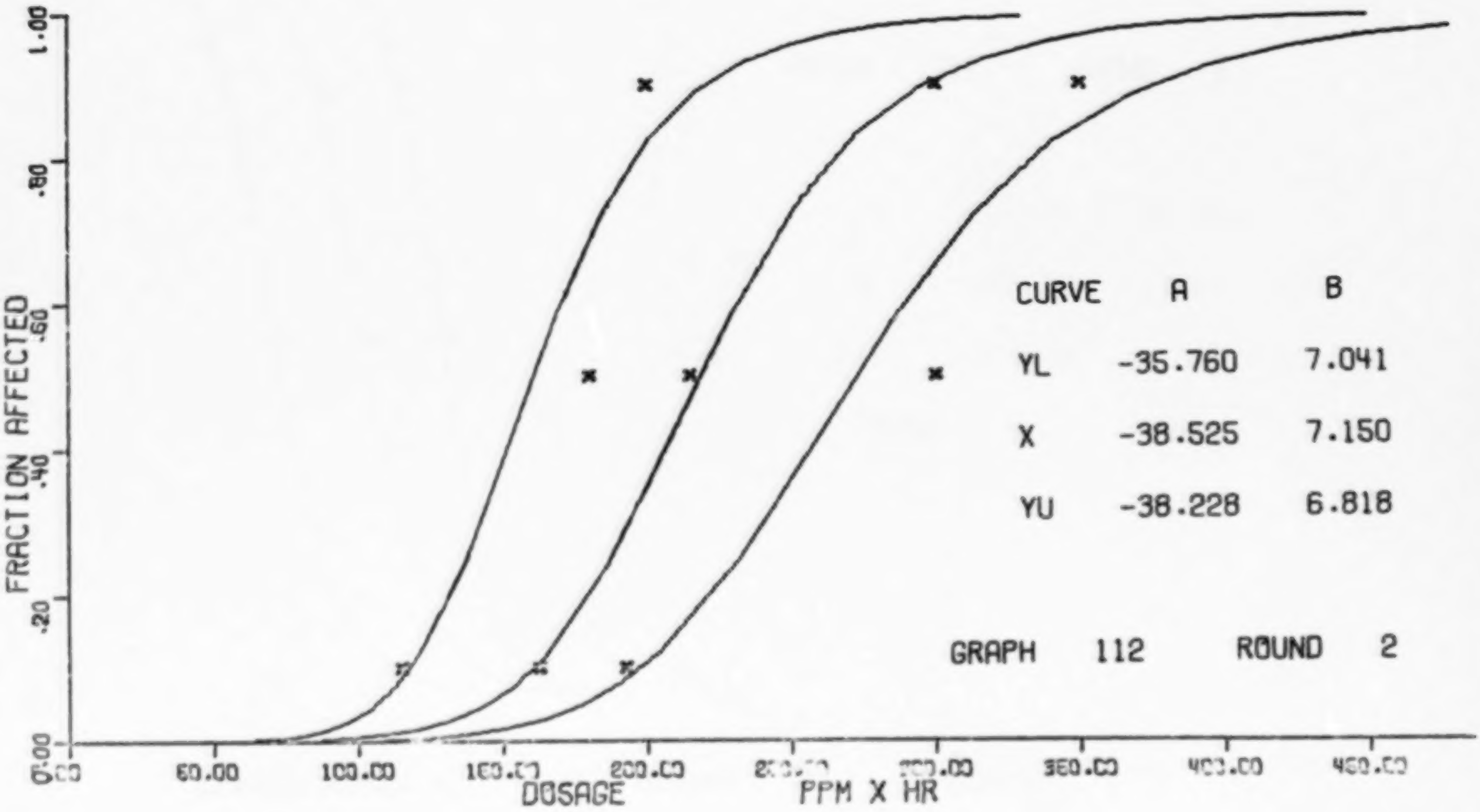
CARBON MONOXIDE ASTHMA DISCOMFORT = mild headache, errors in cognitive function



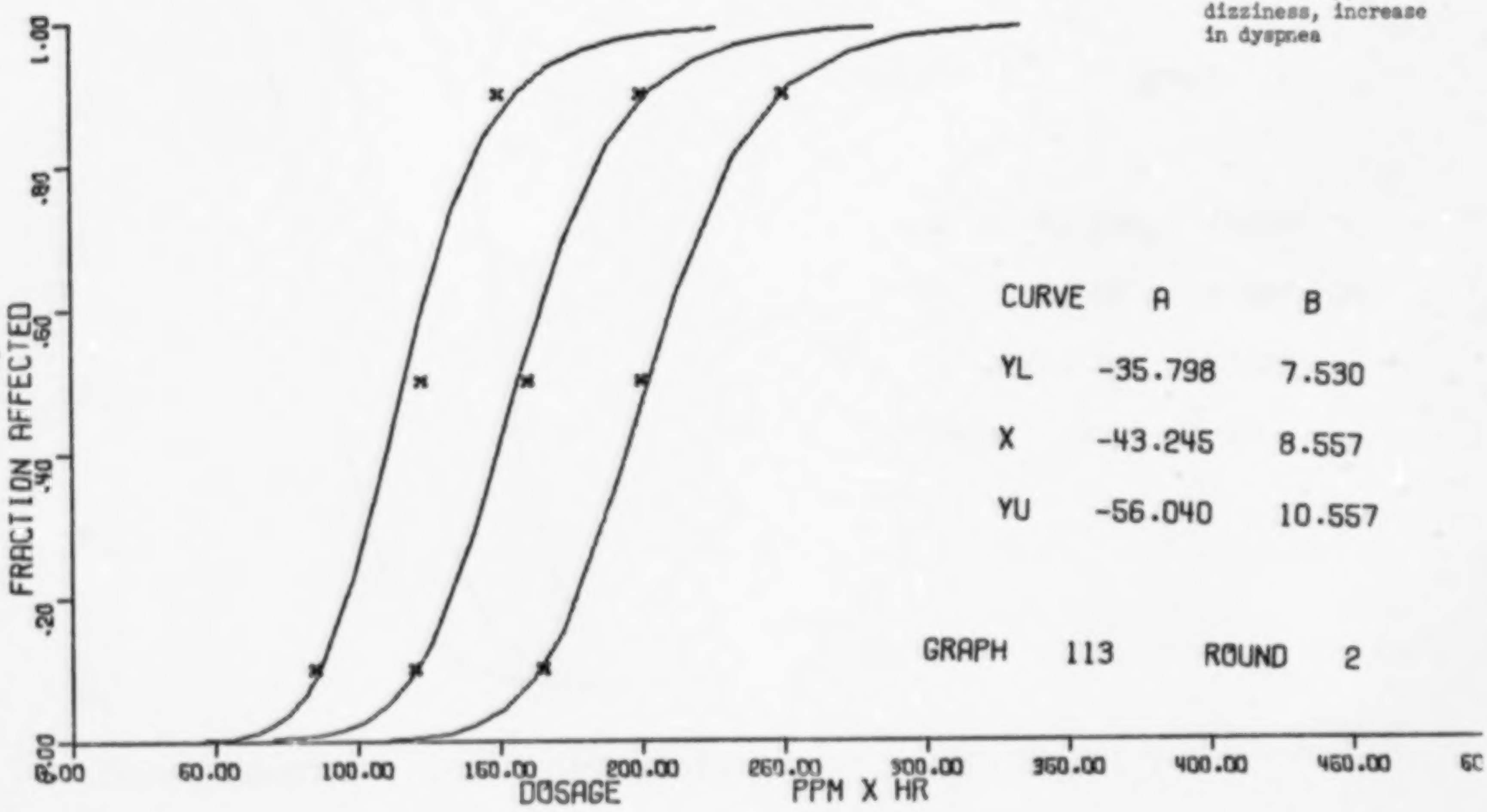
CURVE	A	B
YL	-30.409	7.049
X	-46.106	9.881
YU	-75.795	15.507

GRAPH 111 ROUND 2

CARBON MONOXIDE VIRAL BRONCHITIS INCAPACITY = respiratory failure, coma, convulsions



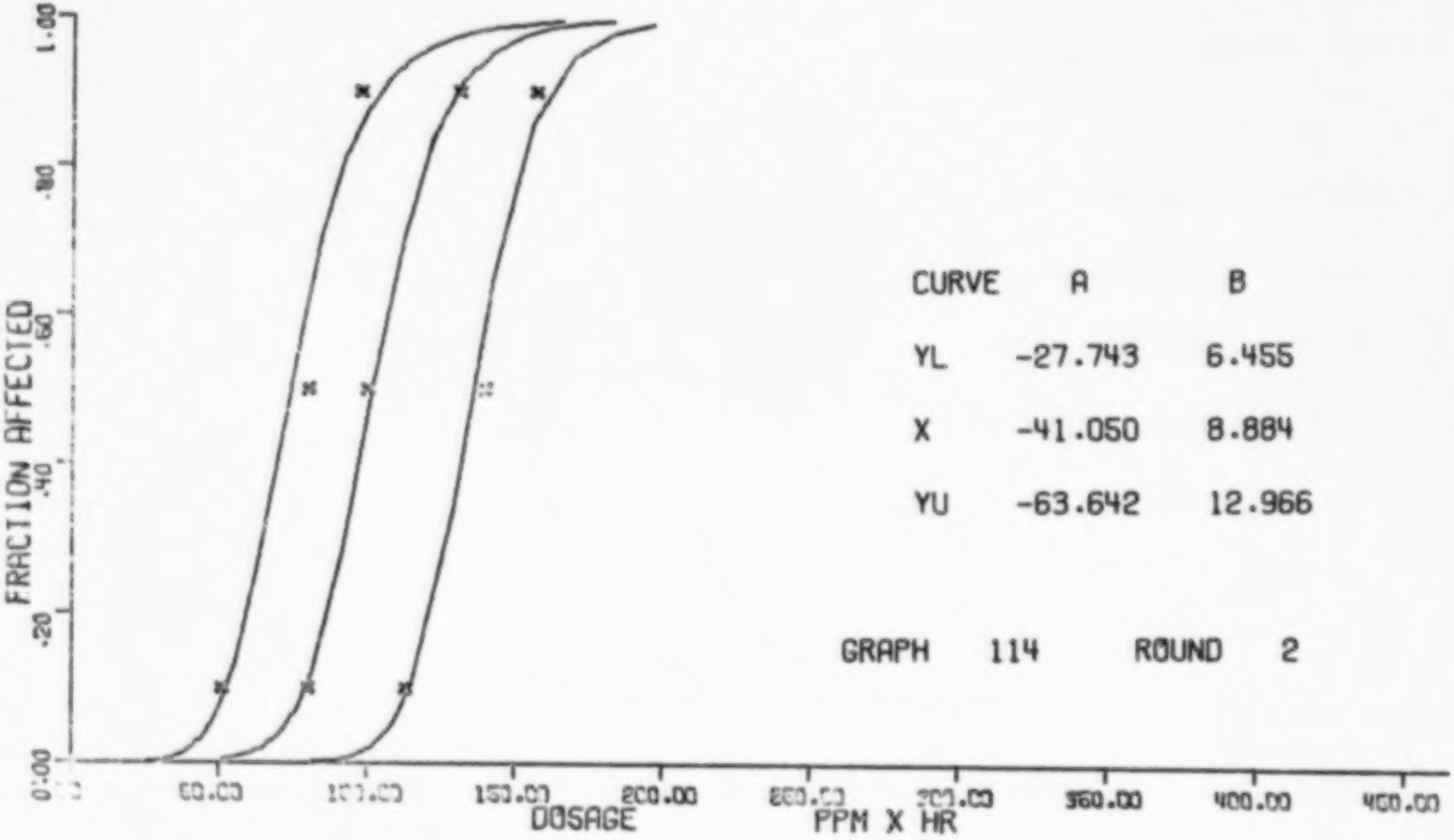
CARBON MONOXIDE VIRAL BRONCHITIS DISABILITY = throbbing headache,
confusion,
irritability,
dizziness, increase
in dyspnea



CURVE	A	B
YL	-35.798	7.530
X	-43.245	8.557
YU	-56.040	10.557

GRAPH 113 ROUND 2

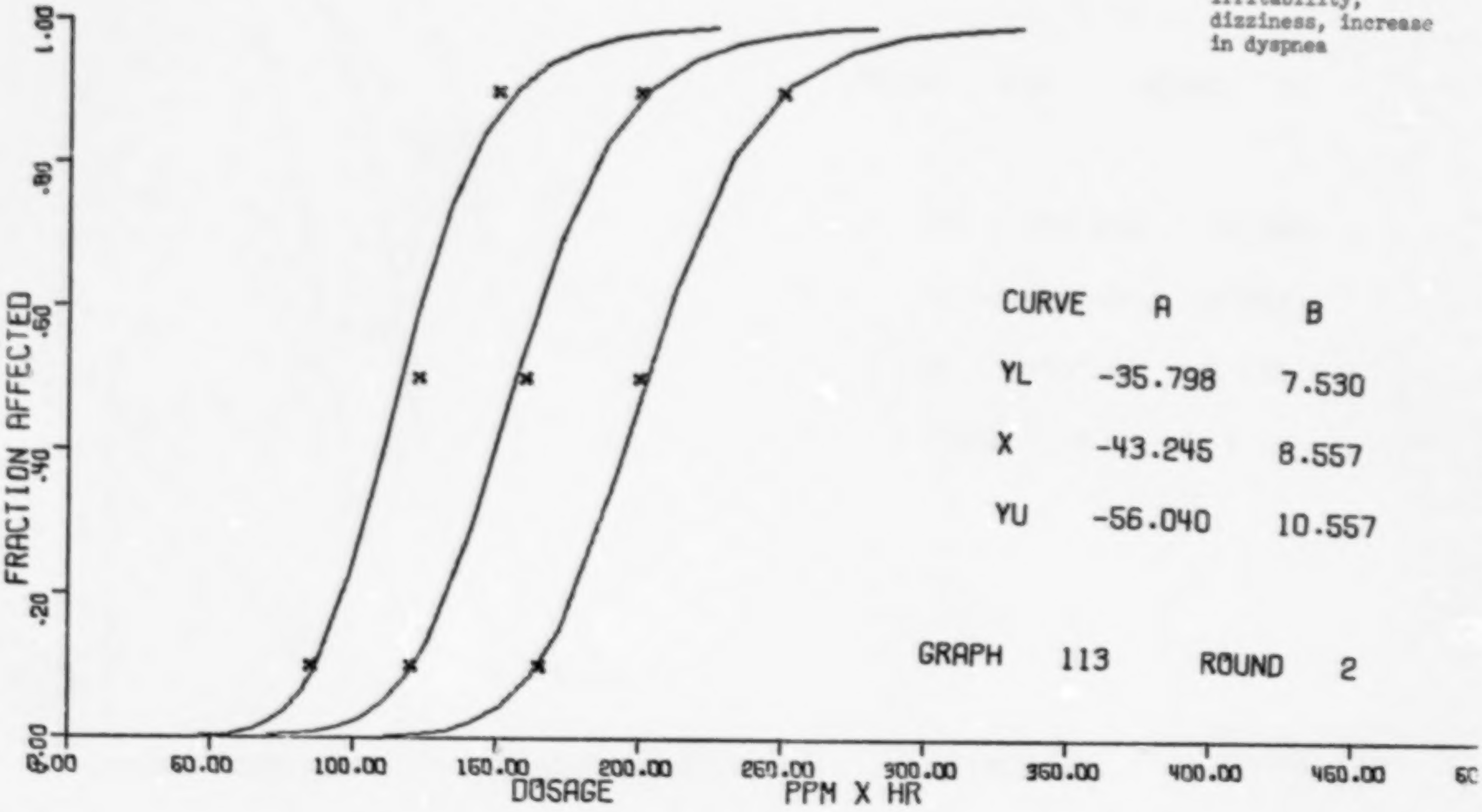
CARBON MONOXIDE VIRAL BRONCHITIS DISCOMFORT = mild headache, errors in cognitive function



CURVE	A	B
YL	-27.743	6.455
X	-41.050	8.884
YU	-63.642	12.966

GRAPH 114 ROUND 2

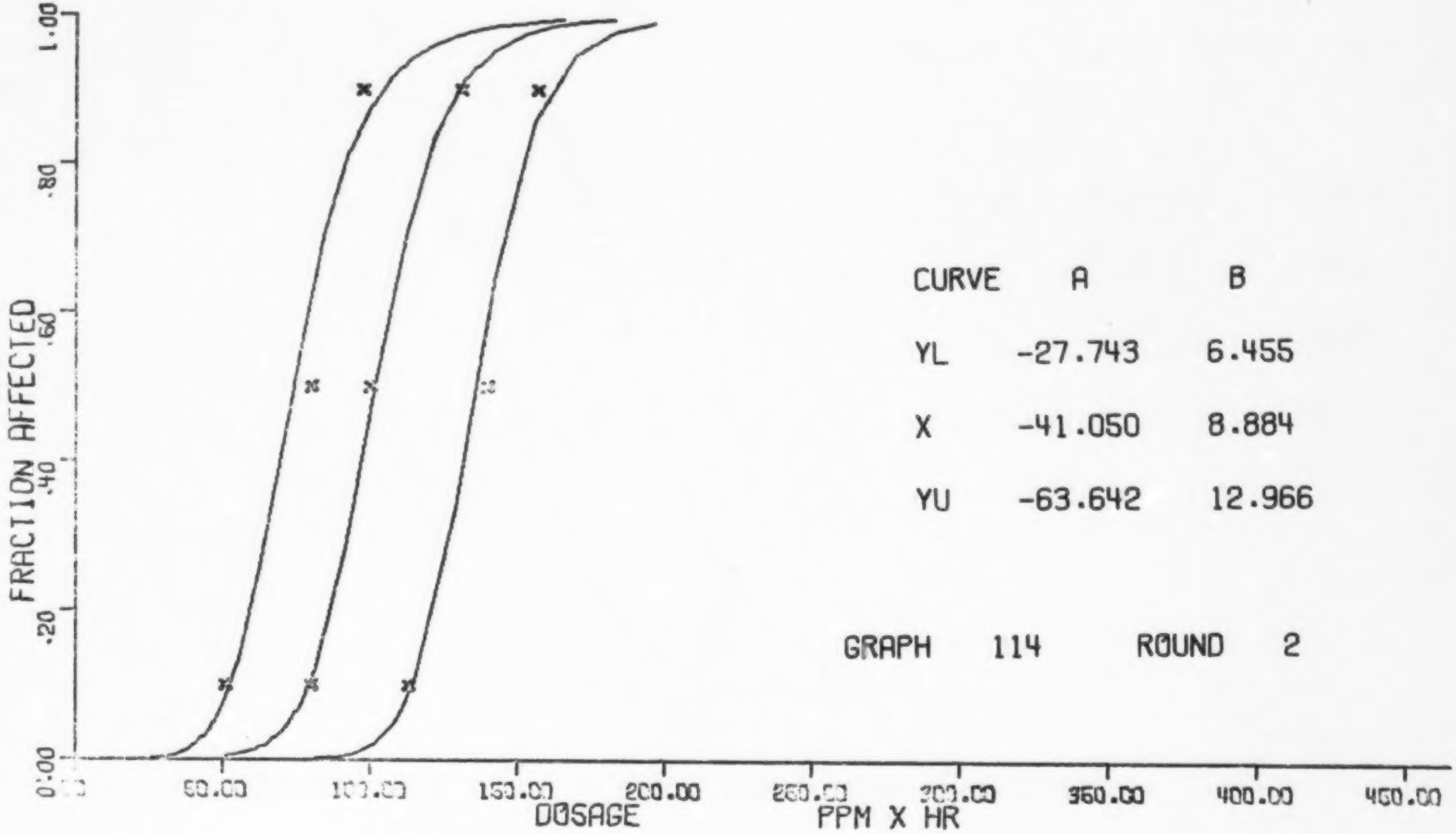
CARBON MONOXIDE VIRAL BRONCHITIS DISABILITY = throbbing headache, confusion, irritability, dizziness, increase in dyspnea



CURVE	A	B
YL	-35.798	7.530
X	-43.245	8.557
YU	-56.040	10.557

GRAPH 113 ROUND 2

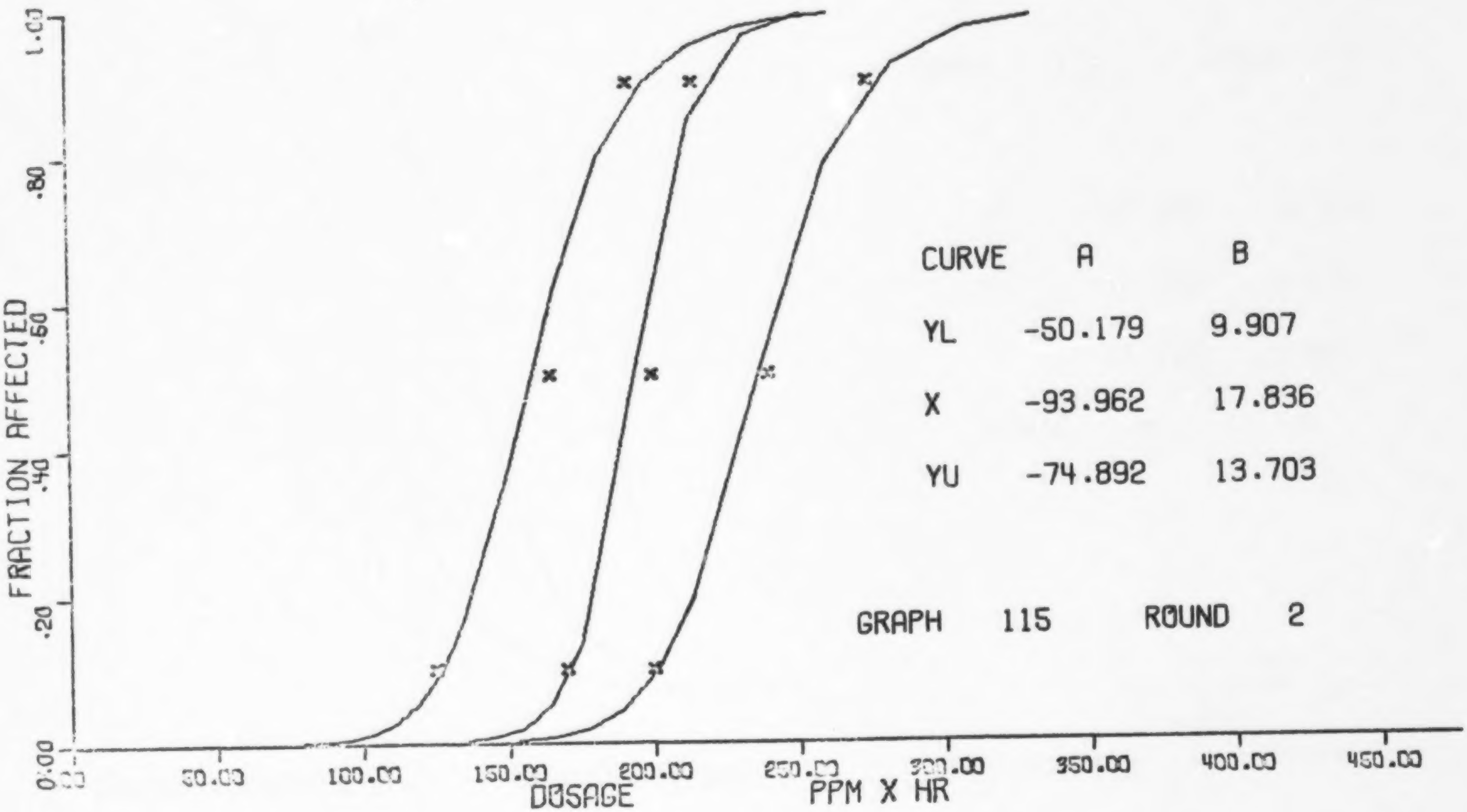
CARBON MONOXIDE VIRAL BRONCHITIS DISCOMFORT = mild headache, errors in cognitive function

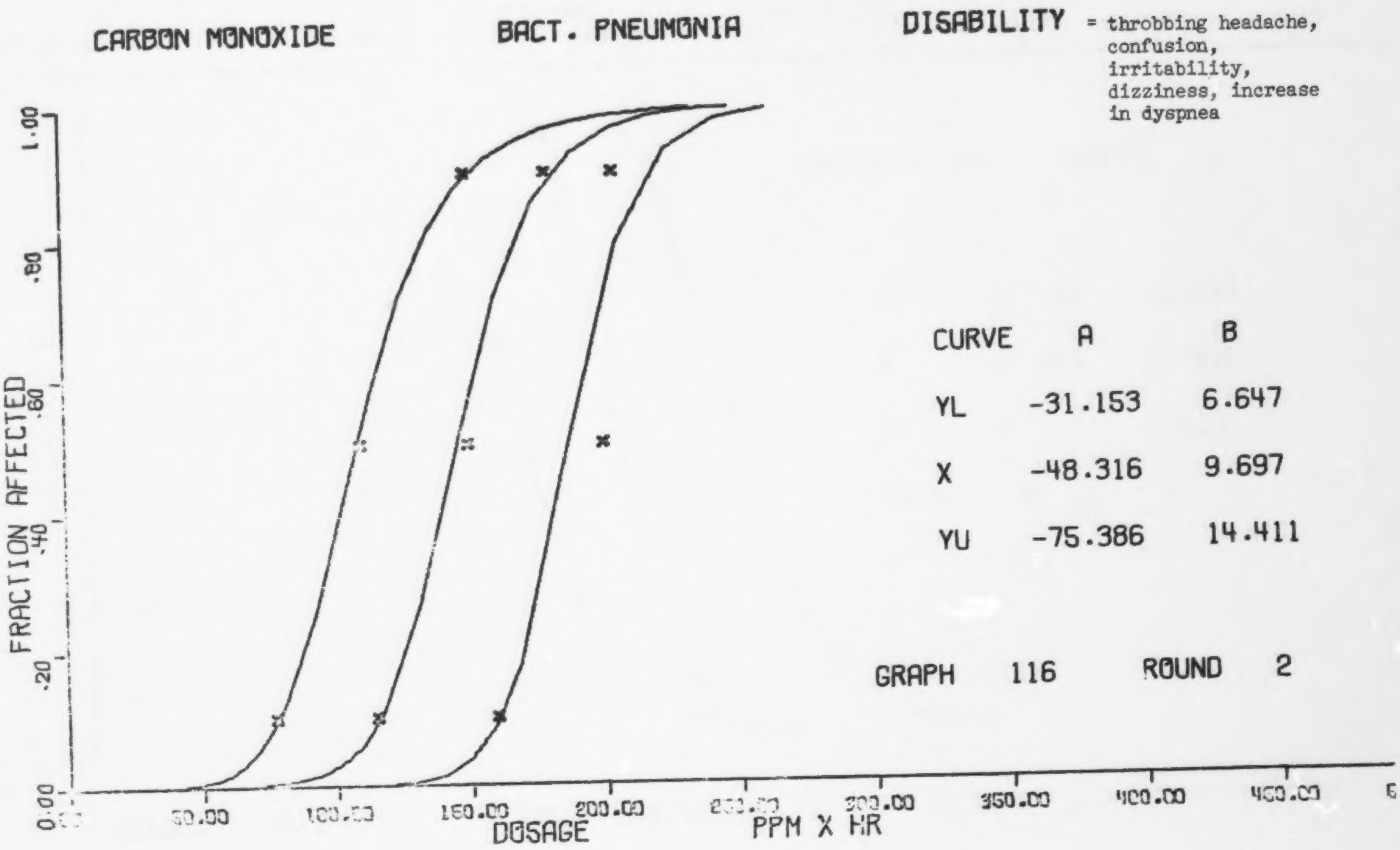


CURVE	A	B
YL	-27.743	6.455
X	-41.050	8.884
YU	-63.642	12.966

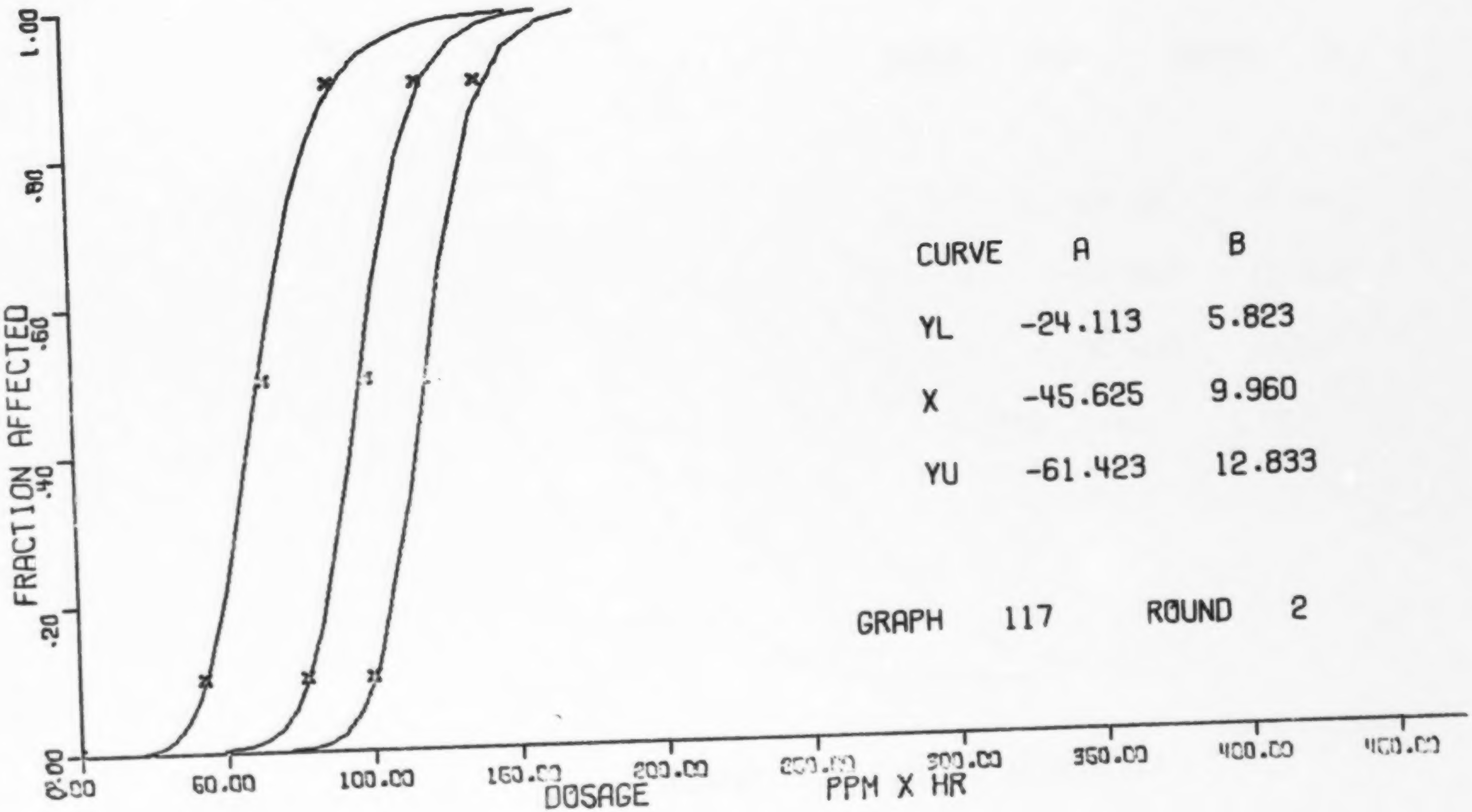
GRAPH 114 ROUND 2

CARBON MONOXIDE BACT. PNEUMONIA INCAPACITY = respiratory failure, coma, convulsions



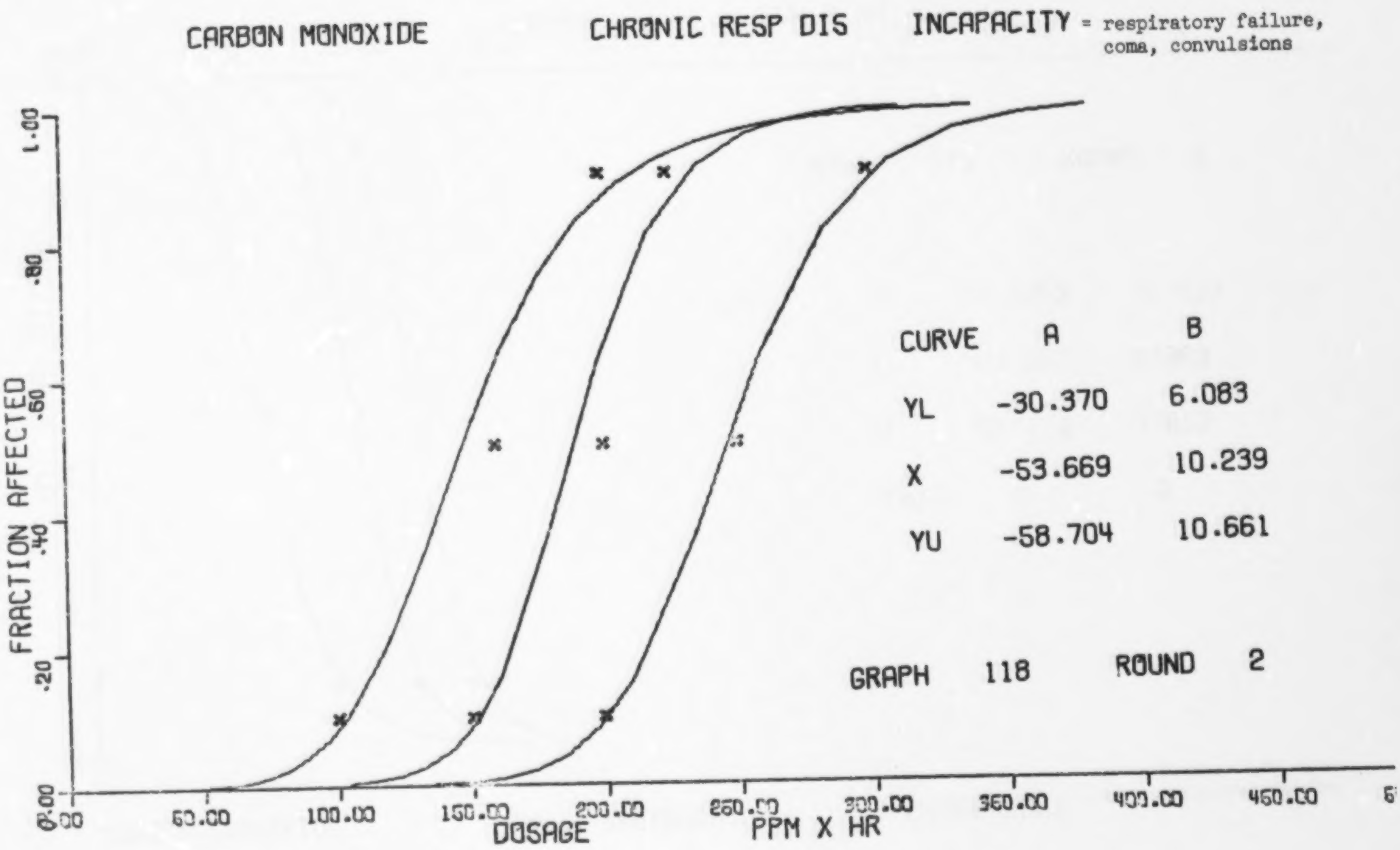

CARBON MONOXIDE
BACT. PNEUMONIA
DISABILITY = throbbing headache, confusion, irritability, dizziness, increase in dyspnea
CURVE A B
YL -31.153 6.647
X -48.316 9.697
YU -75.386 14.411
GRAPH 116 ROUND 2
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
DOSAGE
PPM X HR

CARBON MONOXIDE BACT. PNEUMONIA DISCOMFORT = mild headache, errors in cognitive function

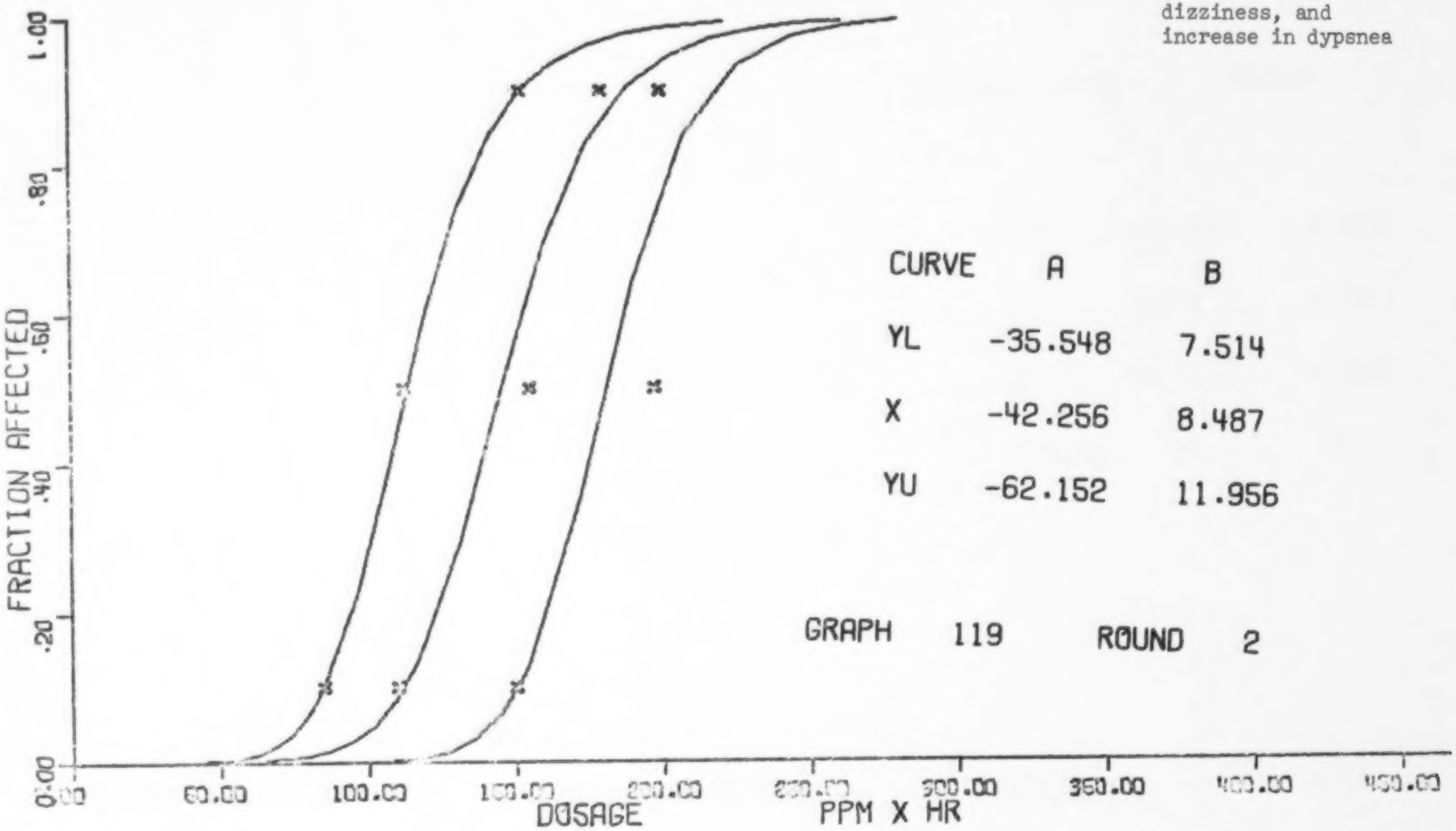


CURVE	A	B
YL	-24.113	5.823
X	-45.625	9.960
YU	-61.423	12.833

GRAPH 117 ROUND 2


CARBON MONOXIDE
CHRONIC RESP DIS
INCAPACITY = respiratory failure, coma, convulsions
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
0.00
60.00
100.00
150.00
200.00
250.00
300.00
360.00
400.00
460.00
6
DOSAGE
PPM X HR
CURVE A B
YL -30.370 6.083
X -53.669 10.239
YU -58.704 10.661
GRAPH 118
ROUND 2

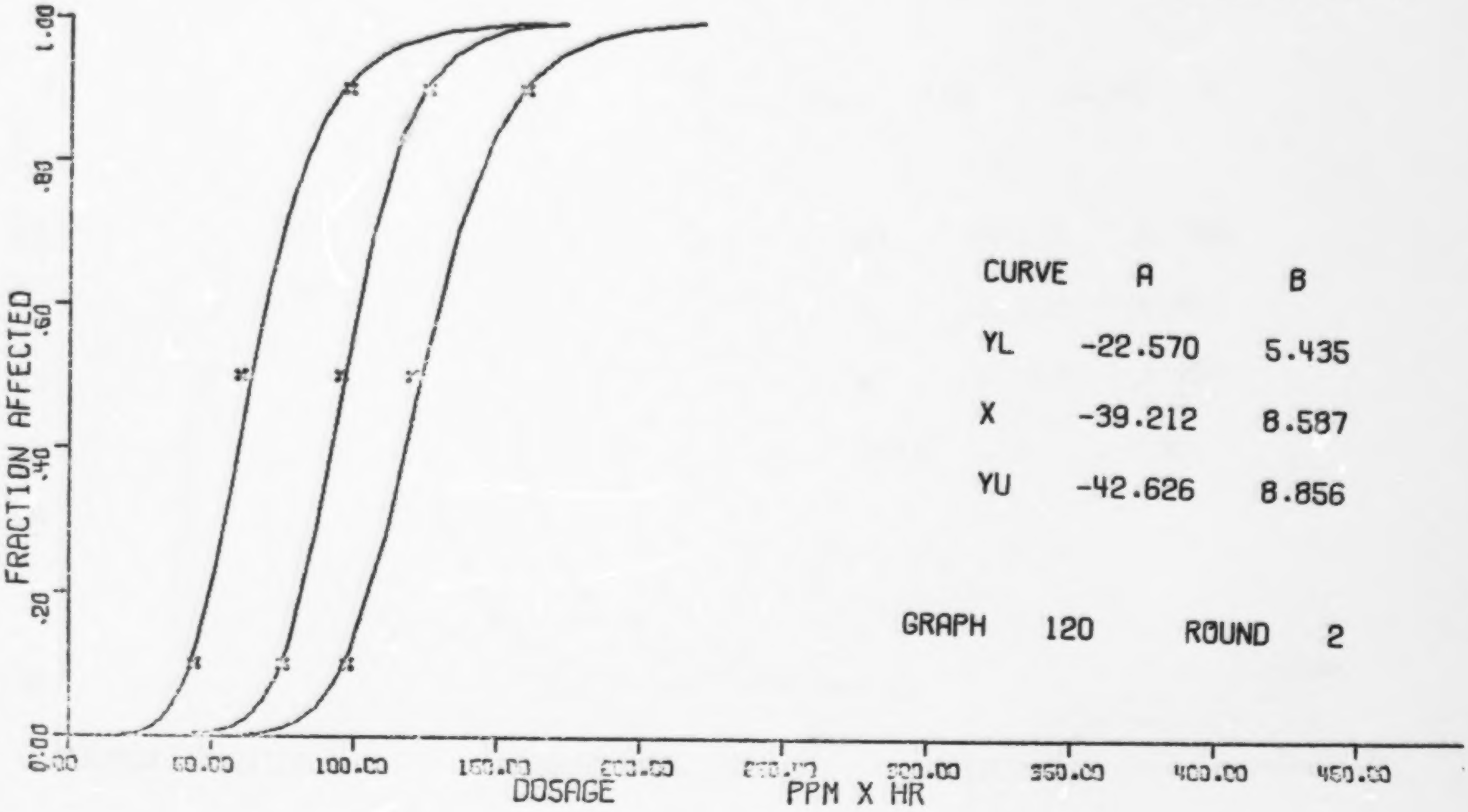
CARBON MONOXIDE CHRONIC RESP DIS DISABILITY = throbbing headache,
confusion,
irritability,
dizziness, and
increase in dypsnea



CURVE	A	B
YL	-35.548	7.514
X	-42.256	8.487
YU	-62.152	11.956

GRAPH 119 ROUND 2

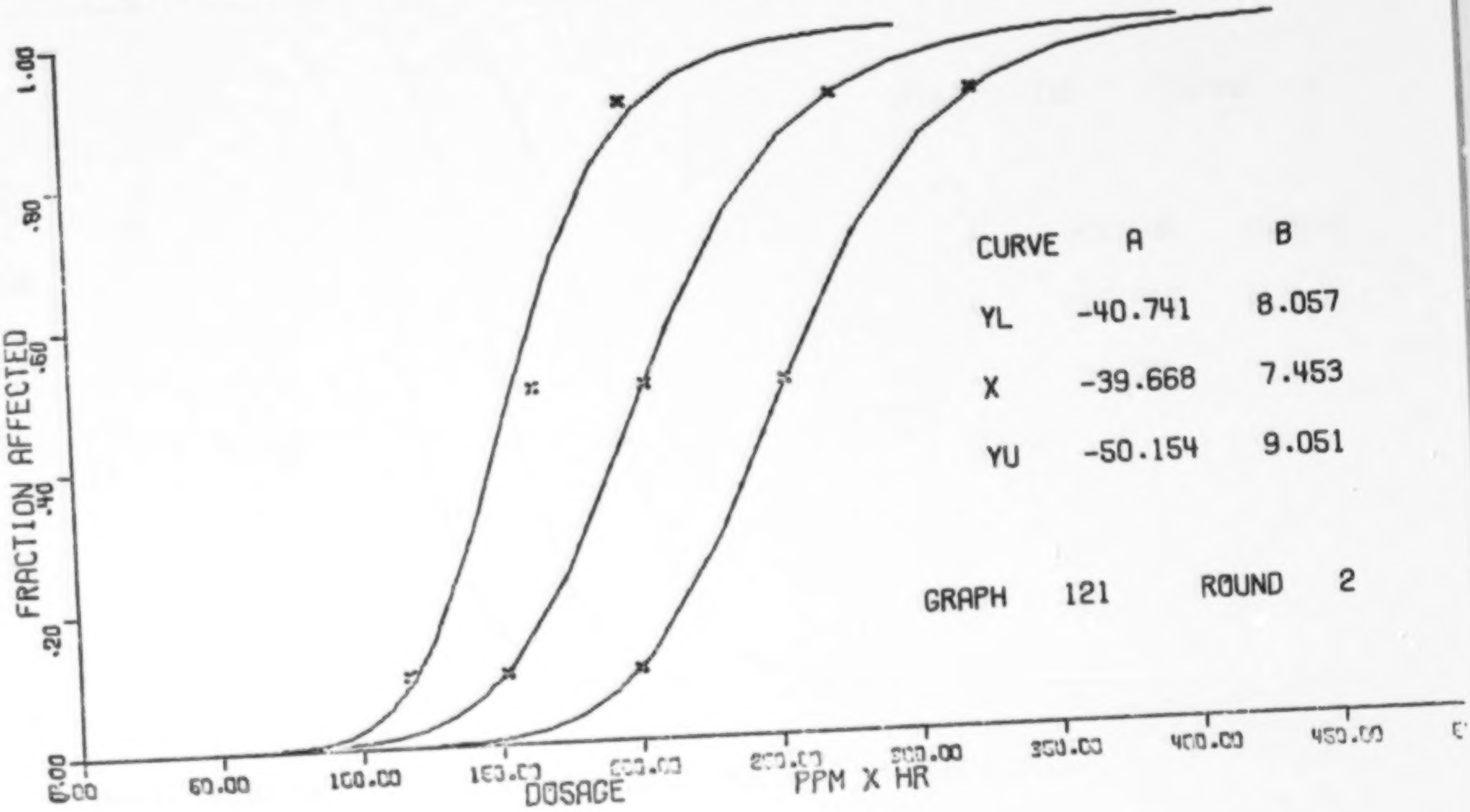
CARBON MONOXIDE CHRONIC RESP DIS DISCOMFORT = mild headache, errors in cognitive function



CURVE	A	B
YL	-22.570	5.435
X	-39.212	8.587
YU	-42.626	8.856

GRAPH 120 ROUND 2

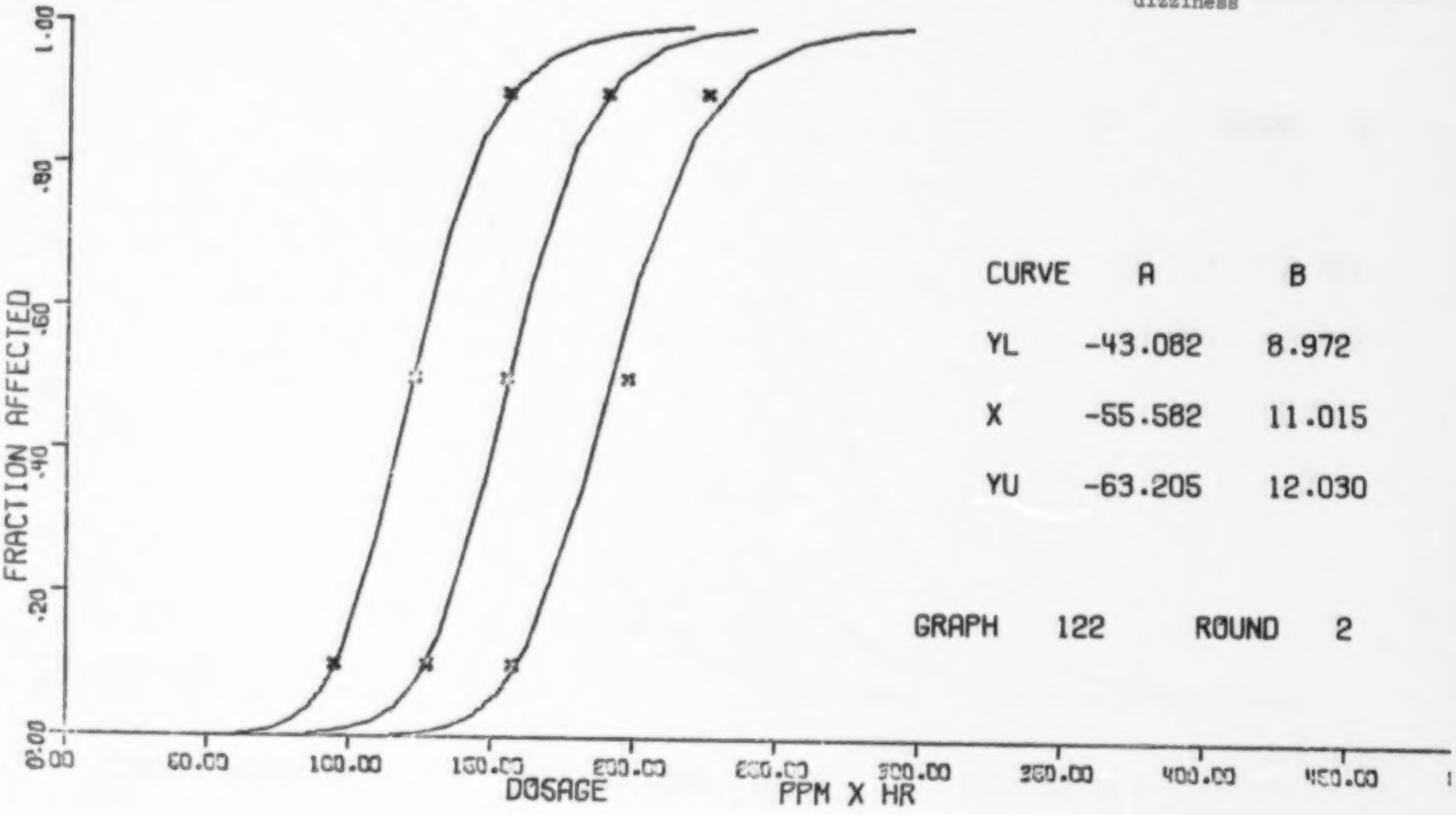
CARBON MONOXIDE M CHRN OBST LUNG INCAPACITY = respiratory failure, coma or convulsions



CURVE	A	B
YL	-40.741	8.057
X	-39.668	7.453
YU	-50.154	9.051

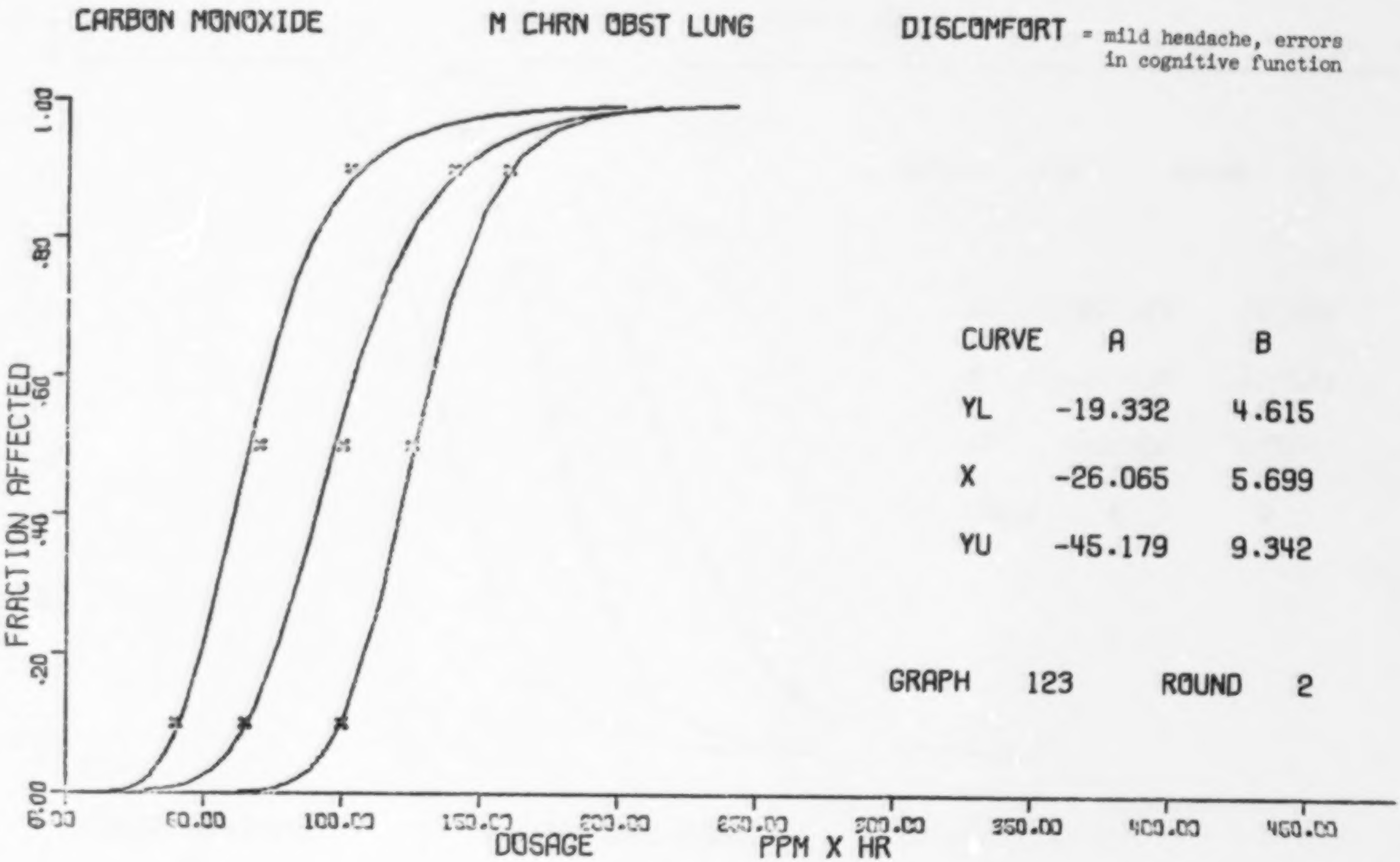
GRAPH 121 ROUND 2

CARBON MONOXIDE M CHRN OBST LUNG DISABILITY = throbbing headache, confusion, irritability, dizziness



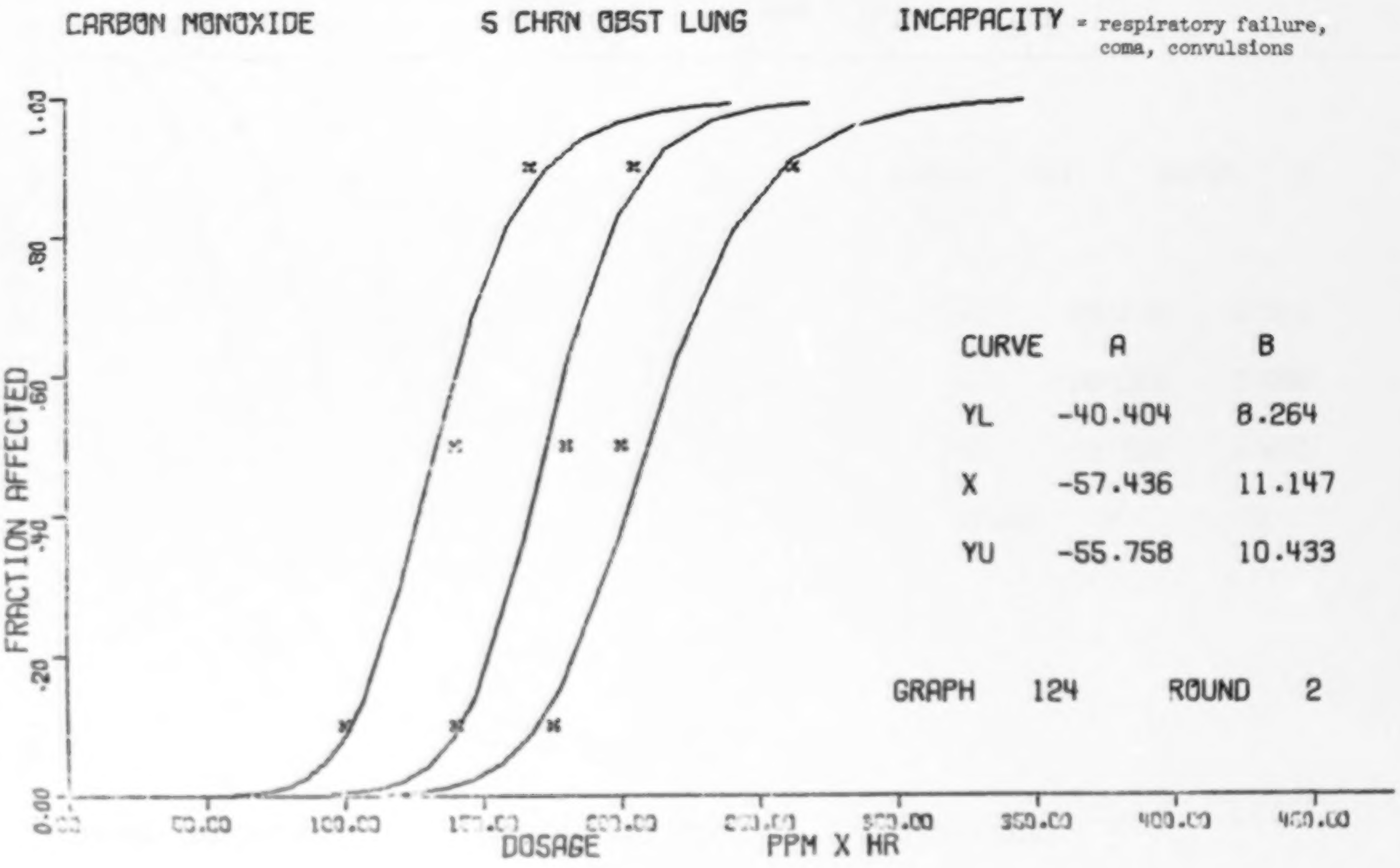
CURVE	A	B
YL	-43.082	8.972
X	-55.582	11.015
YU	-63.205	12.030

GRAPH 122 ROUND 2



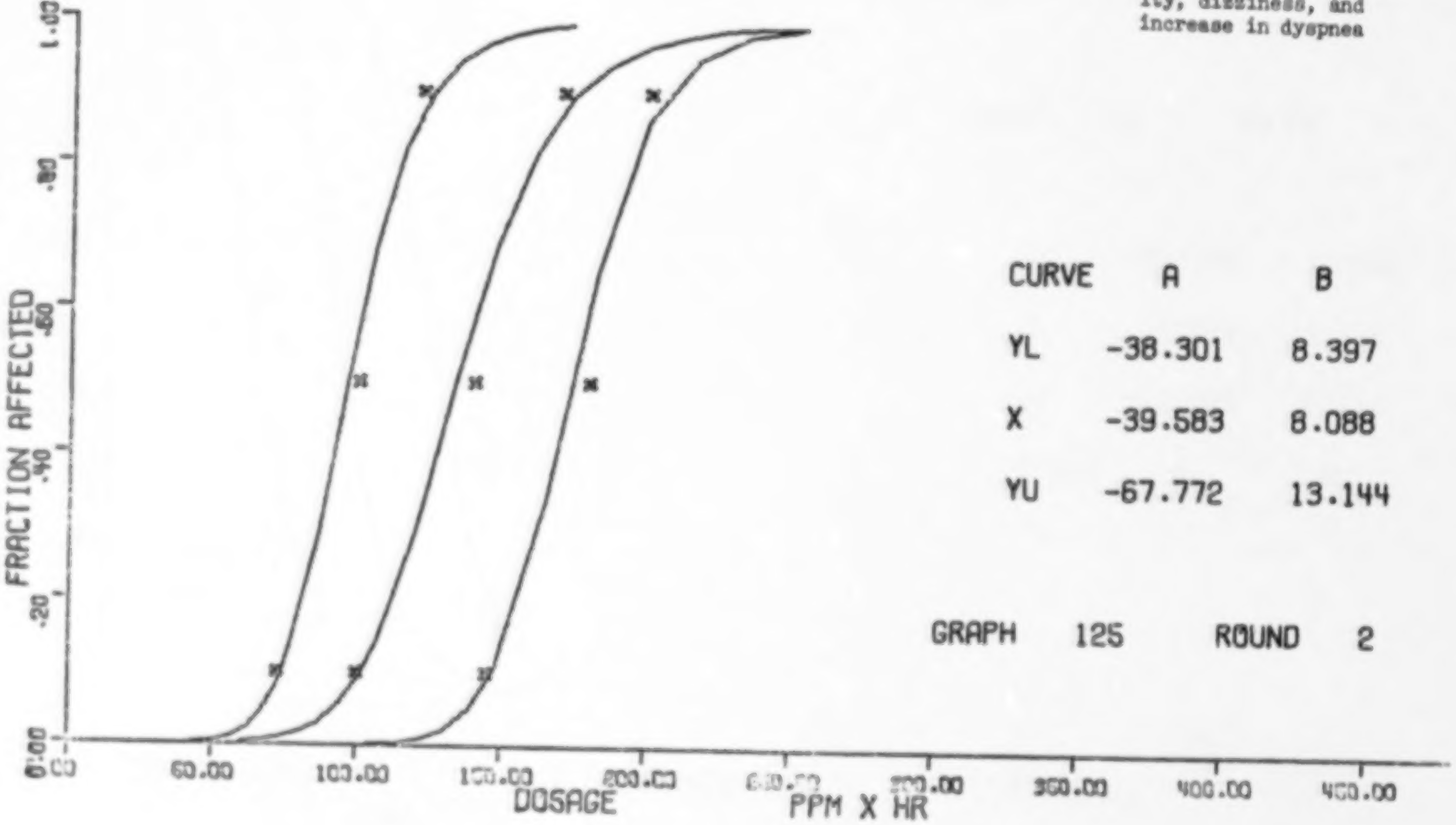
CURVE	A	B
YL	-19.332	4.615
X	-26.065	5.699
YU	-45.179	9.342

GRAPH 123 ROUND 2


CARBON MONOXIDE
S CHRN OBST LUNG
INCAPACITY = respiratory failure, coma, convulsions
FRACTION AFFECTED
0.00
.20
.40
.60
.80
1.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
DOSAGE
PPM X HR
CURVE A B
YL -40.404 8.264
X -57.436 11.147
YU -55.758 10.433
GRAPH 124
ROUND 2

CARBON MONOXIDE S CHRN OBST LUNG

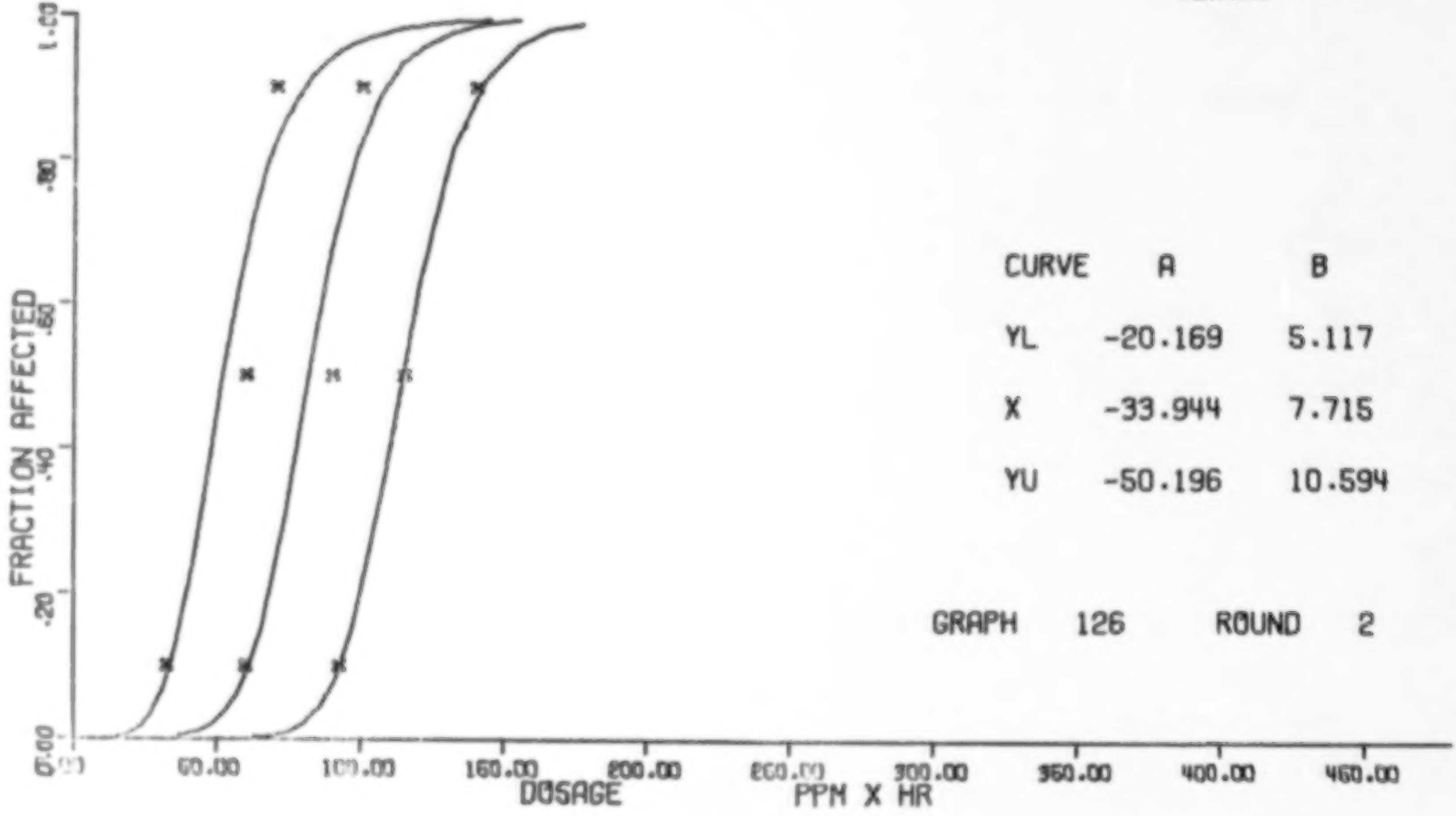
DISABILITY = throbbing headache, confusion, irritability, dizziness, and increase in dyspnea



CURVE	A	B
YL	-38.301	8.397
X	-39.583	8.088
YU	-67.772	13.144

GRAPH 125 ROUND 2

CARBON MONOXIDE S CHRN OBST LUNG DISCOMFORT = mild headache, errors in cognitive function



CURVE	A	B
YL	-20.169	5.117
X	-33.944	7.715
YU	-50.196	10.594

GRAPH 126 ROUND 2